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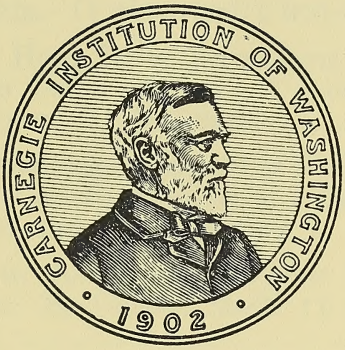

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CONTRIBUTIONS TO PALAEONTOLOGY FROM CARNEGIE INSTITUTION OF WASHINGTON

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I

A NEOCENE EROSION SURFACE IN CENTRAL OREGON

By John P. Buwalda

With one plate and one text-figure

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A NEOCENE EROSION SURFACE IN CENTRAL OREGON [1]

ABSTRACT

A landscape, in the old age stage, termed the Ochoco Erosion Surface, bevels the Columbia lavas and Mascall formation of middle Miocene age at a large angle, and the Rattlesnake lower or middle Pliocene at a small angle, in parts of the Ochoco Range and the John Day country of central Oregon. North of the John Day country the Condon Erosion Surface, locally at least a peneplane, probably but at present not demonstrably the correlative of the Ochoco, truncates the Columbia lavas and perhaps The Dalles formation. A pause in the eventful diastrophic history of this part of the Northwest is apparently indicated by these features. Subsequently, during the present or Dayville cycle, the great gorges and valleys have been excavated.

INTRODUCTION

The observations discussed in this paper were made in the course of the geologic mapping of the Mitchell Quadrangle and the Picture Gorge Special Quadrangle in central Oregon and the incidental study of adjacent areas. The investigations are part of a program of Tertiary history studies being prosecuted under the general direction of Dr. John C. Merriam of the Carnegie Institution of Washington.

Able assistance has been rendered during much of the field work by Mr. Bernard N. Moore.

GEOGRAPHIC FEATURES

A broad basin, largely structural in origin, occupies a large part of central Oregon. Its middle portion is called the Harney Valley. Lying at about 4,000 feet altitude, it is part of the plateau of eastern and central Oregon. Its profiles are gentle.

Immediately north of this broad basin an east-west belt of mountainous country stretches from the higher part of the Blue Mountains of northeastern Oregon westward nearly to the east base of the Cascades. This mountainous zone consists of east-west ridges, and because the valleys between are drained by the branches of the river of that name it is usually known as the John Day country.

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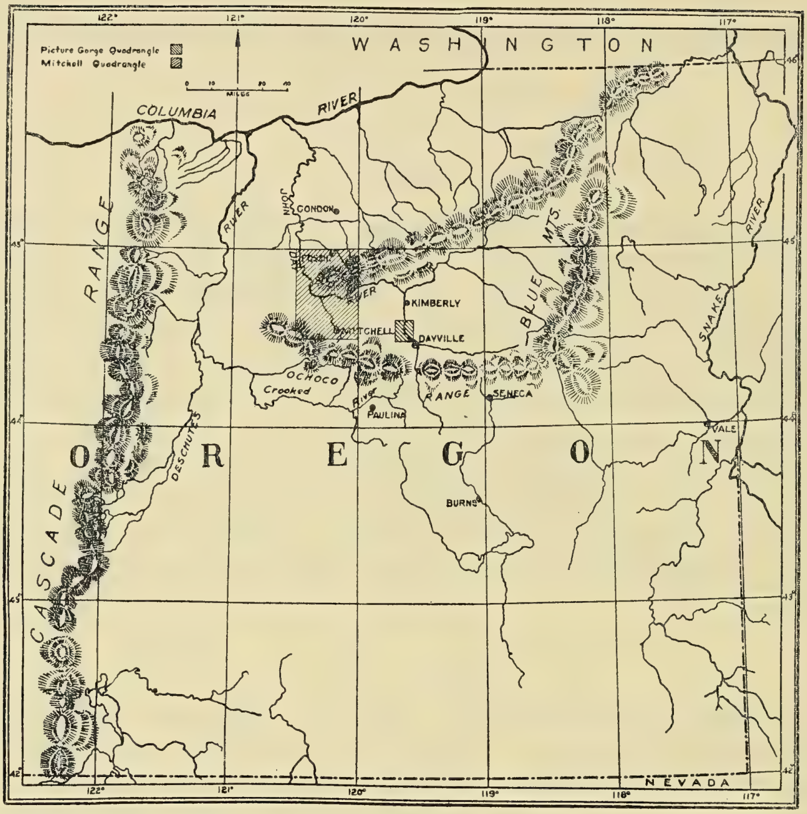
[1] Presented before Geological Society of America, Cordilleran Section, at Berkeley, March 3, 1928.



Plateaus again border this rougher tract on the north, and with declining altitude extend to the brink of the canyon which the Columbia River has incised to varying depth to mark the boundary of Oregon and Washington.

Central and north-central Oregon comprise then these three provinces: two plateau areas with an intervening mountainous belt usually referred to as the John Day region.

AREAL DISTRIBUTION AND STRUCTURE OF THE ROCKS

Physiographic studies can manifestly not be pursued safely without a knowledge of at least the general character and distribution of the rock masses on which the forms under investigation have been developed.

The central Oregon basin, or Harney Valley, is underlain principally by Tertiary lavas, pyroclastics, and continental formations. Of these, the Miocene and earlier formations are folded gently; the Pliocene and Quaternary lavas and sediments are usually only slightly warped.

In the John Day region a greater variety of formations is exposed. The surface rocks of this mountainous tract form three east-west anticlines, with two intervening synclines. The north flank of the most northerly anticline becomes the plateau which extends northward to the Columbia River, and the south flank of the southerly of the three anticlines forms the expansive north slope of the Harney Valley. Minor features of course complicate this structure considerably.

Nearly the whole John Day region seems to have been covered originally by the Columbia lavas. Areally they are still the most important rocks. The Mascall formation, consisting of some two thousand feet of ashy sediments, conformably overlies the lavas in a few areas where it has been protected by downfolding. The Pliocene Rattlesnake formation overlies unconformably both the Mascall and the Columbia lavas in one or more districts. Beneath the Columbia lavas, exposed by deep dissection in only a few areas, the Oligocene sediments of the John Day formation present their upturned edges. The Clarno, consisting of hundreds of feet of basic lavas and pyroclastics, constitutes the surface formation in extensive tracts in the western part of the John Day region, usually along the central part of anticlines from which the cover of later formations has been removed. Chico Cretaceous strata are exposed in small patches in certain localities. Along the gentle south slope of the Ochoco Range, the southern anticline of the John Day region, earlier Mesozoic and Paleozoic strata form the land surface in east-west strips of considerable size. The Chico, John Day, Mascall, and Rattlesnake formations, of sedimentary origin, are of course the weak rocks, and form the lowlands; the pre-Cretaceous, the Clarno, and the Columbia lavas are resistant and commonly constitute the higher parts of the ranges, the plateaus, and the mesas.

North of the John Day region the broad plateau which slopes away gently to the Columbia River is underlain almost entirely by Columbia lavas.

OCHOCO EROSION SURFACE

Distribution of Remnants

Of the three provinces mentioned as constituting central and north-central Oregon, the middle one—the elevated and folded John Day country—has been deeply dissected, approximately to the stage of early maturity in the erosion cycle. The stream valleys are still gorges or canyons in the more resistant rocks, but have been widened to narrow valleys in the John Day and Mascall formations (Plate I, fig. *A*). The valley bottoms are sometimes flat alluviated floors, in other cases they are rolling or hilly up to the contact with the more resistant formation which makes the adjoining hill or mountain.

The dissection of the John Day region is due not alone to its higher elevation and the consequently greater precipitation upon it. To the east of the region the Elk Range, highest part of the Blue Mountains, receives still greater rainfall, and the forks of the John Day, receiving a considerable part of this, have therewith developed enlarged excavating powers.

The main branches of the John Day River have been cut to levels considerably below the nearby margins of the plateaus which lie to the north and south of the dissected John Day region. The sloping plateau on the south which rises gradually from the floor of Harney Valley northward attains general elevations, in the crest of the Ochoco Range, of 2,000 to 2,500 feet above Bridge Creek and the main John Day. As a consequence tributaries of these streams are reaching vigorously back into the plateau by headward erosion. The heads of these tributaries have advanced southward, in many cases far beyond the line of maximum heights of the Ochoco Range.

Strong contrast marks the topography north and south of the sinuous drainage divide. To the north, as indicated earlier, the land forms are those of early maturity: steep slopes, divides often sharp, general ruggedness. Southward from the drainage divide of the Ochoco Range the surface is one of gentle slopes, broad divides, and low relief. The southward drainage is of rather low gradient. Broad valleys occur, and meadows, such as Big Summit Prairie in the summit region south of Mitchell (Plate I, fig. *B*).

Some of the flat and gently sloping surfaces on this subdued upland are unquestionably structural in origin. The Columbia lava particularly gives rise to strikingly smooth dip slopes because of its peculiar habit of degradation through complete removal of successive sheets, flow by flow, over large areas. But the surface of relatively low relief here under discussion extends over areas not underlain by the Columbia lavas. To the west and southwest of the summit crossing of the Prineville-Mitchell road the Clarno formation underlies the surface; its detail of form is quite different, but the more subdued character of the upland surface still contrasts strongly with the rugged and dissected topography cut on the same formation north of the divide by the tributaries of the John Day.

The old erosion surface extends along the south slopes of the Ochoco Range from the Big Summit Prairie region south of the Mitchell Quadrangle eastward through the Paulina, Izee, and Seneca regions, where Dr. Packard and Mr. Lupher have been studying Cretaceous and pre-Cretaceous formations, for an unknown distance toward the Snake River region. Several years ago the writer observed what appeared to be an old surface ascribable to a former erosion cycle on the south slopes of the Blue Mountains, perhaps midway between Burns and Vale.

When traced down the south slopes of the Ochoco Range south of the Mitchell Quadrangle the old surface becomes progressively more dissected, due to invasion headward by the tributaries of the rejuvenated Crooked River. This stream and the Deschutes, which it joins, have cut deep trenches during the present cycle, below remnants of the old erosion surface.

Within the John Day region, in which the topography has advanced in the present cycle to early maturity, but few residual areas of the old surface have been recognized. The Rattlesnake formation, of middle Pliocene age, was deposited in a shallow valley, the floor of which was part of the old erosion surface. North of the areas where the old surface is covered by these sediments, between Picture Gorge and Kimberly, remnants of what is believed to be the same surface truncate the Columbia lavas and stretch eastward and westward from the rims of the 2,500 foot canyon through which the John Day flows at this point.

The plateau north of the John Day country has the physiographic characteristics of youth. High grade canyons lead to the Columbia and the John Day Rivers. They often end headward in the midst of a large expanse of undissected country. The undissected interstream areas are very extensive; well-defined drainage has developed on only a fraction of the whole territory. The critical question, however, is whether the extensive flat surfaces actually truncate the structure in the underlying Columbia lavas. Loess and soil commonly obscure the relation. At many localities structure and surface are parallel, as nearly as can be determined. It is almost inconceivable, however, that this broad expanse of flat country was moulded in the present cycle of erosion, for only part of it has well-defined drainage at the present time, and that drainage certainly appears to be destroying the flat surface, not forming it.

The surface is believed to bevel the lavas but at a small angle, but with the loess cover it has not been possible thus far to find a clearly demonstrable case.

It has sometimes been assumed that flat plateaus in the Columbia lava region are simply the original upper surface of lava accumulation, but it is of course unreasonable to suppose that such a land surface would lie exactly at base level during the whole long interval since middle Miocene time. It would either long since have been degraded, if it lay above base level, or have been buried by sediments if below. It might be supposed that it was buried by sediments and only recently exhumed; but in that case sizable remnants of the sediments should be found on some of the flat interstream areas, which are often miles wide.

DESIGNATION AND TYPE AREAS

Since the old surfaces here described are extensive for tens or scores of miles and represent a significant chapter in the physical history of central and north-central Oregon, it seems advisable to name and define them.

The old surface on the south slope of the Ochoco Range is properly designated the Ochoco Erosion Surface. The type area is the Big Summit Prairie district, south of Pisgah Peak, and south of the southern part of the Mitchell Quadrangle.

The surface north of the John Day country, sloping down to the brink of the Canyon of the Columbia River may be the correlative of the Ochoco, but this can not at present be demonstrated, and in view of the uncertainty the name Condon Erosion Surface is proposed for it, from the town of Condon which is situated on it. The type area may be taken at that locality.

The present difficulty in correlation of the Condon surface with the Ochoco arises from the absence of known Mascall and Rattlesnake deposits from the Condon region, so that the age of the surface can not be so precisely determined. The Condon surface has not been traced into the areas of Ochoco surface, and it may not be possible to do so.

State of Development Reached

The Ochoco erosion surface was, before its deformation and partial destruction, by no means a peneplane. Certain parts of it may have approached that condition, but in the type area the relief over distances of several miles was several hundred feet. Broad valleys formed part of its surface, and hills and ridges rose above the general level. Now that parts of the surface have been uplifted to 5,000 or 6,000 feet, these hills have become the high points of the country and as peaks have been given specific names. They stand, as does Mount Whitney, above the uplifted old surfaces of the upper Kern in the southern Sierra Nevada. If the Ochoco region were unwarped, however, it would merely be considered hilly in parts and it would have the aspect of an old age surface.

The Condon surface, if restored by filling in the canyons which have begun to trench it, would have less relief than the Ochoco. It was in late old age when uplifted; it approached the peneplane stage over considerable areas.

AGE

Since the Ochoco Erosion Surface bevels the Columbia lavas and Mascall formation, as well as all earlier formations, it is of course post-Mascall, and hence post Middle Miocene in age. More precise determination of its age rests, however, upon its relations to the lower or middle Pliocene Rattlesnake formation. Unfortunately these strata are not present in the areas where the erosion surface is best represented. East of Picture Gorge, however, the Rattlesnake has been faulted down into the Columbia lavas and the erosion surface has quite certainly beveled the lavas subsequently, leaving protected strips of the sediments. Southeast of Mitchell, near the summit of the Ochoco Range, rhyolites, presumably the correlative of the Rattlesnake rhyolites lying along the Mitchell-Dayville road a few miles to the north, are cut by the Ochoco Erosion Surface. While the evidence is not entirely conclusive it seems to indicate that the erosion surface was finished in middle or upper Pliocene time.

While in geomorphic usage erosion surfaces are often designated by the geologic date of completion, it should be pointed out that, when the Ochoco surface is called a middle or an upper Pliocene erosion surface because it bevels lower or middle Pliocene rocks, this does not necessarily mean that it was developed entirely during this brief fraction of a period. The folding of the region which occurred in post-Mascall pre-Rattlesnake time was far more intense, if we compare the dips of the Mascall and the Rattlesnake, than any post-Rattlesnake pre-Erosion Surface deformation. The Rattlesnake formation, while it consists in part of lavas poured out over the pre-Rattlesnake landscape, was largely a valley filling; it thins for instance along the sides of the John Day Valley, and its upper members extend out over the older formations much farther than the lower beds. While its rather coarse nature indicates that considerable relief still existed in some parts of the region it is clear from the above relations that the larger part of the geologic labor involved in truncating the large pre-Rattlesnake folds had been performed previous to Rattlesnake time and that during and after the deposition of the Rattlesnake the erosional activity was mainly one of completing and perfecting the surface.

Since the Rattlesnake formation is not known to occur north of the John Day country it has not been possible to determine the age of the Condon Erosion Surface, the probable correlative of the Ochoco, much more precisely than that it is post-Columbia lava in age. It is highly probable, however, that it bevels The Dalles formation, which has recently been shown to be middle Neocene in age.[1]

[1] J. P. Buwalda and B. N. Moore, *Age of the "Satsop" and The Dalles Formations of Oregon and Washington,* Science, vol. 66, Sept. 9, 1927.

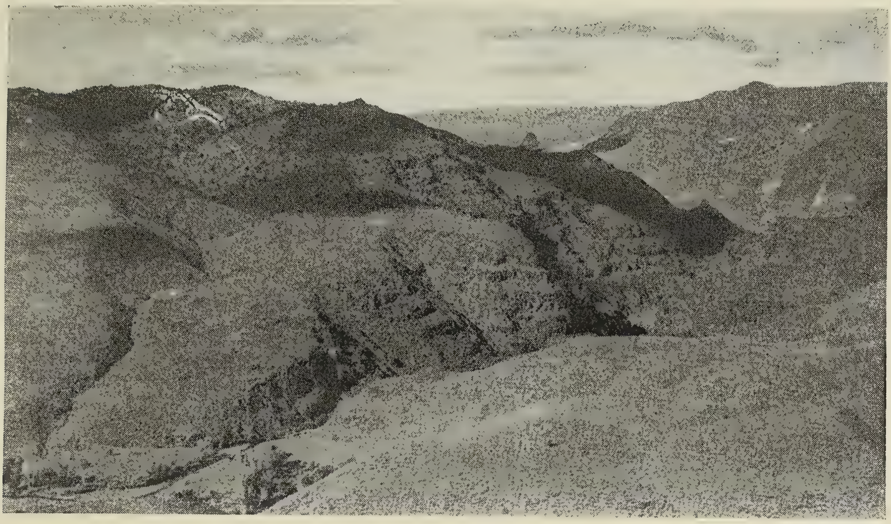
The upper limit for the age of the Ochoco surface is set as middle or upper Pliocene, primarily because of the extent of the excavation and dissection accomplished subsequently. Enormous gorges and quite broad and deep valleys have been developed in the John Day country and the Ochoco Range. The Condon surface has been similarly modified.

SUBSEQUENT MODIFICATION

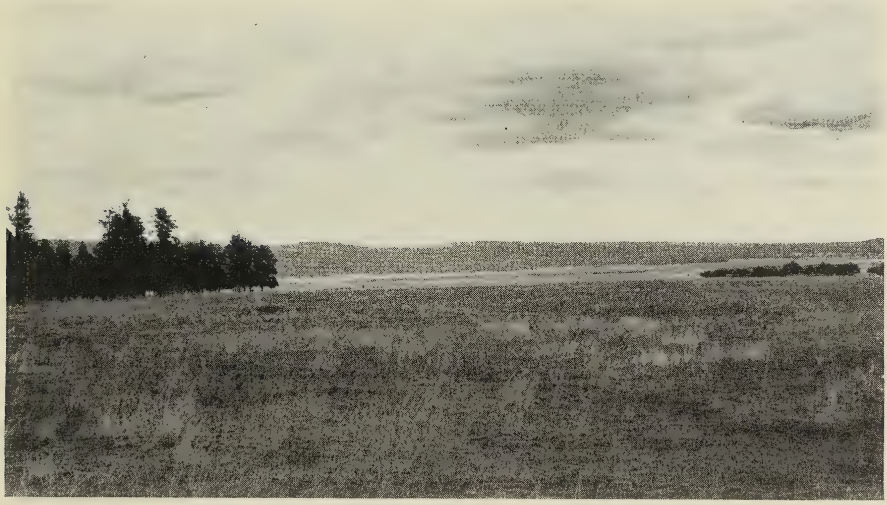
As in most other elevated parts of the western United States which have external drainage, the dominant erosional process in the John Day region is vigorous dissection and degradation. In this present cycle, termed the Dayville cycle, land surfaces produced earlier are being rapidly destroyed. This is of course primarily due to uplift in the course of the late Cenozoic topographic revolution which has been and is affecting the whole of western North and South America. The tributaries of the Columbia have been attacking the region from the north, those of the John Day from the west, and the branches of the Deschutes from the south and southwest. While the John Day, due to several favoring conditions, has carried the task to early maturity in the John Day region itself, the destruction of the surface has been only well begun in the Ochoco region to the south and the Condon country to the north.

A second modification of the old erosion surfaces, presumably concurrent with the uplift, has been the post-Rattlesnake folding along east-west axes. This was much less intense than the pre-erosion-surface folding of the Neocene, for the dips in the Rattlesnake seldom exceed a few degrees, while the Mascall and Columbia lava dips are sometimes above 30 degrees. The post-Rattlesnake folding is, however, responsible for the main features of the present relief—the anticlinal ridges like the Ochoco range, and the synclinal valleys like the John Day. Low broad swells on both the Ochoco and the Condon surfaces are quite certainly due to this late Tertiary and Quaternary deformation. Faults cut the Rattlesnake formation and have quite certainly dislocated the Ochoco Erosion Surface also in areas where no Rattlesnake is present.

Slight modification by loess accumulation on the Condon surface has occurred, and post-erosion-surface lavas have accumulated to some extent on parts of the Ochoco surface, but these have affected the form of the land to only a trivial degree.



A—Looking down Rock Creek (middle foreground) and valley of John Day River (in distance) below Picture Gorge. Mature topography; 2,000 feet relief. Ochoco Erosion Surface largely destroyed; probable remnants on skyline in center.



B—Big Summit Prairie, on the gentle south slope of the Ochoco Range, 15 miles south of Mitchell, Oregon. Looking northeast. Tributaries of the John Day River are invading this old-age surface vigorously from the north. This region is the type area of the Ochoco Erosion Surface.

II

THE DALLES AND HOOD RIVER FORMATIONS, AND THE COLUMBIA RIVER GORGE

By John P. Buwalda and Bernard N. Moore

With one text-figure

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THE DALLES AND HOOD RIVER FORMATIONS, AND THE COLUMBIA RIVER GORGE[1]

INTRODUCTION

A definite assignment of geologic dates to the main events of the Cenozoic history of the Columbia Gorge and Columbia plateau—vulcanism, sedimentation, folding, erosion—is manifestly possible only if we know the age of at least some of the formations. Because of their stratigraphic position, the ages of The Dalles beds and of the gravels heretofore known as Satsop lying between the Columbia River lavas and the volcanic Cascades formation in the Gorge have critical value for historical purposes. Some doubt has arisen in recent years regarding the extreme youth heretofore assigned to these sedimentary formations and the consequent recency of the physiographic development of the Columbia River Gorge. The writers and Mr. John H. Maxson devoted about ten days in July 1927 to a study of the region extending from somewhat east of The Dalles to west of Hood River. Efforts were concentrated on securing fossil material from the formations lying on the Columbia lavas and on determining the relations of these formations to each other. A very brief preliminary statement of results has been published.[2]

The investigation was made under the general direction of Dr. John C. Merriam, President of the Carnegie Institution of Washington, as part of a broad program of Tertiary history studies in the Northwest.

GENERAL GEOGRAPHY

After flowing westward across the lava plateaus for more than a hundred miles, along the boundary between Washington and Oregon, the Columbia River crosses three other persistent north-south physiographic divisions on its way to the Pacific: the Cascade Range, the Willamette Valley depression, and the Coast Ranges. A powerful stream, which apparently flowed along approximately the route it now follows before the present mountains existed, it was able to maintain its way by downcutting during the uplift of the western ranges. As an antecedent river it developed the only gateway in the Northwest through the Cascade Range. Through the impressive Columbia River Gorge, passes the drainage of large parts of four states and of extensive areas in southwestern Canada, and important railroads and

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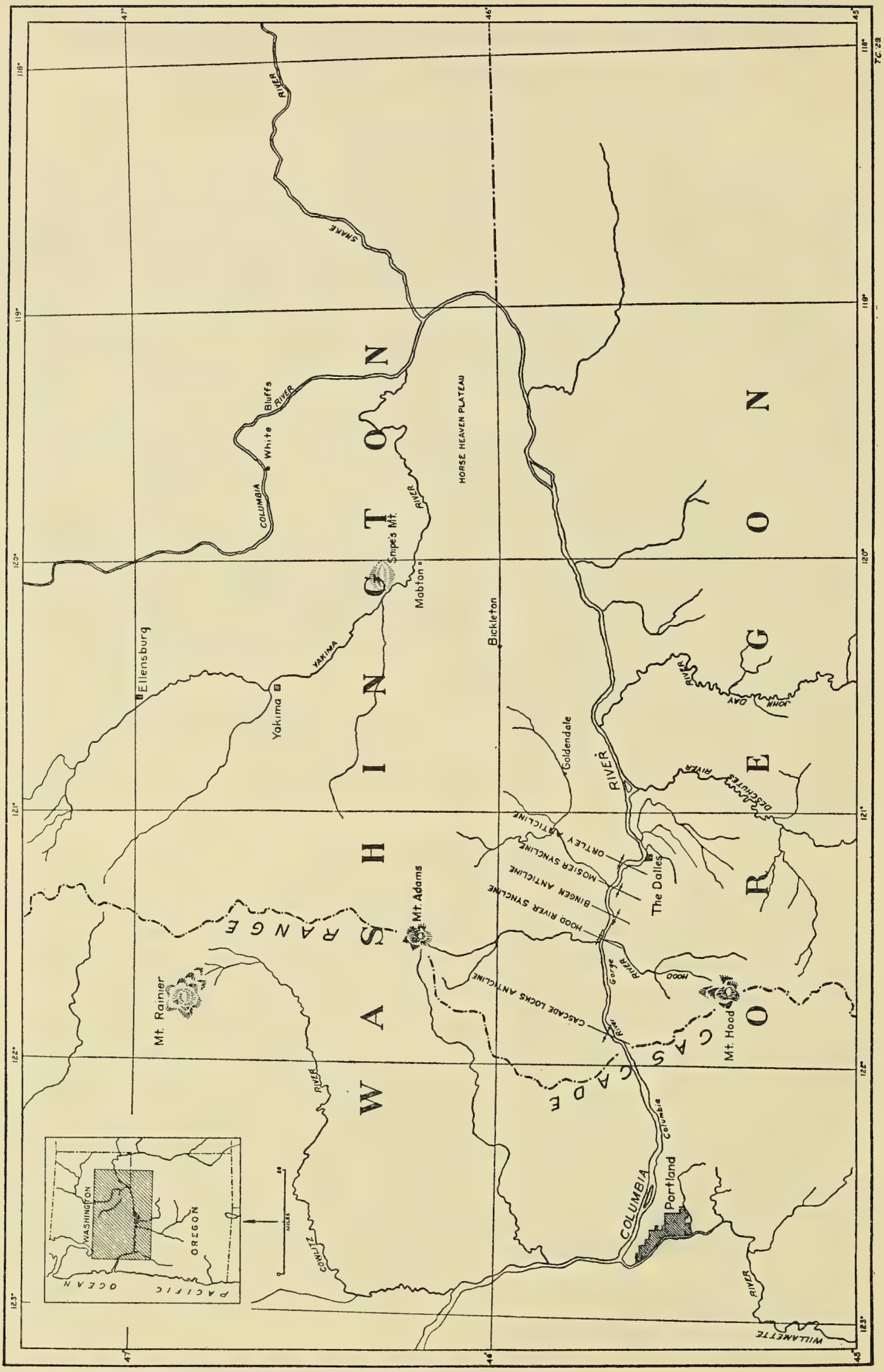
[1] Presented before the Cordilleran Section, Geological Society of America, at Berkeley, California, March 3, 1928.

[2] Science, vol. 66, September 9, 1927.


WASHINGTON
OREGON
CASCADE RANGE
Mt. Rainier
Mt. Adams
Mt. Hood
Ellensburg
Yakima
YAKIMA
RIVER
Snipe's Mt.
Mabton
Bickleton
HORSE HEAVEN PLATEAU
White Bluffs
COLUMBIA
RIVER
SNAKE
RIVER
Goldendale
RIVER
The Dalles
ORTLEY ANTICLINE
MOSIER SYNCLINE
BINGEN ANTICLINE
HOOD RIVER SYNCLINE
CASCADE LOCKS ANTICLINE
Gorge
RIVER
HOOD
RIVER
JOHN DAY
RIVER
DESCHUTES
RIVER
COLUMBIA
Columbia
Portland
COWLITZ
RIVER
WILLAMETTE
RIVER
PACIFIC OCEAN
WASHINGTON
OREGON
MILES
50
47°
46°
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highways as well. The city of The Dalles is situated on the south side of the Columbia River near its entrance into the Gorge; Hood River, also on the south bank, lies about twenty miles to the west within the Gorge.

OUTLINE OF THE GEOLOGY

The formations constituting the Cascade Range in the Gorge region and the adjacent parts of the plateau to the east are all of Cenozoic age.

In the core of the range the oldest strata are exposed over a limited area. These belong to the Eagle Creek formation,[1] regarded as of Oligocene or lower Miocene age, and consisting of 2,000 feet or more of andesitic pyroclastics. Its base lies below the level of the Columbia.

Above the Eagle Creek formation lie the Columbia River basaltic lavas, with a thickness ranging from 1,000 to 2,000 feet, and usually consisting of between ten and twenty flows. They are strikingly exposed along the walls of the Gorge and form the plateaus to the east of the Cascade Range. Gravels, sometimes several hundred feet thick and heretofore known as the Satsop, overlie the basalts in the Gorge. Just east of the mouth of the Gorge and south and east of the city of The Dalles a series of basic agglomerates, tuffaceous sandstones and gravels some hundreds of feet in thickness rest upon the basalts, apparently conformably. These strata have been known as The Dalles beds. The Cascades formation, consisting mainly of basic lavas and tuffs, overlies the earlier formations unconformably and forms in many places the upper parts of the walls of the Gorge.

These formations have been moderately folded, as may be clearly observed in the walls of the Gorge. The structure of the Cascade Range in this impressive cross-section consists of three anticlines and the intervening synclines. The axis of the western and broadest of the arches crosses the Columbia near Cascade Locks, and the name Cascade Locks anticline is here proposed for it. East of it lies the syncline in which Hood River is situated; it may well be designated by that name. The two narrower and sharper anticlines to the east, termed the Bingen and Ortley by Williams, are separated by a structural and topographic trough which, because that town is situated in it, may be called the Mosier syncline. The aggregate width of the two synclines and anticlines lying east of the Cascade Locks anticline is less than half the width of the Range; these smaller eastern folds are also lower. At the eastern mouth of the Gorge at The Dalles, on the east flank of the Ortley anticline, the Columbia lavas and overlying strata flatten to the relatively gentle dips of the plateau.

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[1] R. W. Chaney, *Ecologic Significance of the Eagle Creek Flora of the Columbia River Gorge*, Jour. Geol., vol. 26, 577-598, 1918.

Our knowledge of the stratigraphy, structure and history of the Columbia River Gorge has been greatly increased during the last decade by the publication of the results of studies made, in part in collaboration, by J. Harlen Bretz and by Ira A. Williams. While the present authors do not agree with all opinions expressed, these publications are important and very interesting contributions.

AGE OF THE DALLES FORMATION

F. H. Knowlton stated that the age of The Dalles formation is Eocene.[1] R. W. Chaney commented on a collection of leaves from The Dalles beds: "The modern aspect of the leaves of this flora suggests its Pliocene or Pleistocene age." [2]

J. H. Bretz regarded it as probable that The Dalles beds are a local phase of the Satsop formation;[3] the latter he considered Quaternary in age.[4]

The writers were led to search for mammalian fossil remains in The Dalles beds through the report of Thomas Condon[5] that fragmentary bones had been found, and because a few promising badland exposures had been seen during an earlier examination of the region by one of the authors. The fossil material secured in 1927 is unfortunately scanty and fragmentary, but gives valuable information regarding age.

A horse tooth, a proboscidean fragment and a fused artiodactyl metapodial were found in nearly horizontal massive gray tuff estimated to lie about 500 feet above the base of The Dalles beds. The locality is about 2 miles southeast of The Dalles, about 0.25 mile southeast of the Charles Calkins home, on the southwest side of the road and about 75 feet above it. The horse tooth was found in place.

A portion of a proboscidean tusk was found on the north side of the Columbia River. It occurred in place in Satsop gravels lying nearly flat in the Mosier syncline. The locality is about 2 miles west of Lyle, in low bluffs just north of the highway.

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[1] *Fossil Flora of the John Day Basin,* U. S. Geol. Surv. Bull. No. 204, 112, 1902.

[2] *Preliminary Notes on Recent Tertiary Collections in the West* (Abstract), Geol. Soc. Am. Bull., vol. 32, No. 1, 137, 1921.

[3] *The Satsop Formation of Oregon and Washington,* Jour. Geol., vol. 25, 454, 1917.

[4] Idem, 466, and Geol. Soc. Am. Bull., vol. 28, No. 1, 170, 1917.

[5] *The Dalles Group,* in *Oregon Geology,* 1910.

Report on Horse Tooth from The Dalles Beds of Oregon,
by Chester Stock

The tooth from The Dalles beds is a hypsodont lower cheek-tooth of a horse. While unfortunately the outer side of this specimen is largely destroyed, the metaconid-metastylid column and the entoconid are fairly well preserved.

The tooth appears to have been well cemented. It is comparable in size to $P\bar{4}$ in the type of *Hipparion condoni* from the Ellensburg formation. The size and shape of the metaconid-metastylid column and the type of internal groove between these two cusps as exhibited on the wearing surface remind one rather strongly of *H. condoni.* In *Merychippus* this groove is frequently deep and V-shaped, whereas in The Dalles specimen the groove is broad and open. The entoconid is quadrate in cross-section, in which respect the tooth may again be regarded, perhaps, as slightly more progressive than *Merychippus* and more like *Hipparion.*

Having in mind the fact that the present material is fragmentary, the characters presented by The Dalles tooth would seem to suggest approximately an Upper Miocene or Lower Pliocene stage in the evolution of the Equidæ.

That The Dalles formation is not Eocene, as F. H. Knowlton suggested is moreover quite clear from the fact that it overlies the Columbia River lavas, known to be about middle Miocene in age.

The approximately upper Miocene or lower Pliocene age of The Dalles formation is corroborated by other lines of evidence. The Dalles formation is not definitely known to be conformable on the Columbia lavas, but its strata are at least essentially parallel to the lavas; it has been folded to the same degree. In view of the tectonic activity prevalent throughout the whole west coast region throughout tertiary time, this similarity in the degree of deformation points to probable close relationship in date of deposition; hence approximately upper Miocene. A second line of evidence is the rather remarkable lithologic similarity of The Dalles beds to the Ellensburg of central Washington, now known to be late Miocene or lower Pliocene.[1] Both formations are apparently parallel to the underlying basalts, both are made up in large part of rounded volcanic river gravels and peculiar bluish and gray cross-bedded tuffaceous sandstones and ash beds. The composition of the volcanics in the gravels is somewhat different, but this may indicate merely a somewhat different source. A third indication that The Dalles formation is middle Neocene rather than Quaternary is its induration. A comparison of the induration and resistance to erosion of numerous Neocene and Quaternary formations in the Pacific Coast States, both of marine and continental origin, has led the writers to the conviction that when extensive exposures can be studied it is usually possible to differentiate in a broad way on the basis of these characteristics between Miocene, Pliocene and Quaternary formations, and certainly between middle Neocene and Quaternary formations. The nature of the materials must naturally be taken into account, as must the loading from overlying formations when the thickness of these can be determined. It is also clear that judgments from limited exposures can not be relied upon, and that the induration of a formation deposited late in one period will often not differ materially from that of strata laid down early in the succeeding period. But with all these reservations, the induration of The Dalles formation is equal to that of other middle Neocene formations of the Columbia plateau region, such as the Ellensburg, Mascall, Payette and Virgin Valley. Its induration is enormously greater than that of Quaternary formations like the Ringold, the Quaternary gravels of the Gorge and the Portland region, and the Quaternary marine formations of the Oregon and California coast. It is on the whole more indurated than the Pliocene Rattlesnake formation of the John Day region.

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[1] Paper by John C. Merriam and John P. Buwalda in course of publication.

All the evidence converges to indicate a middle Neocene age for The Dalles formation.

AGE OF THE "SATSOP GRAVELS" OF THE COLUMBIA RIVER GORGE

J. H. Bretz applied the name Satsop formation in 1915 to a deposit of stream gravels in the Chehalis Valley of western Washington.[1] Its age was thought to be Quaternary because of its unconformable relation to Eocene and Miocene sediments, its limitation as a valley filling, and its probable equivalence to Quaternary formations at various localities on the Washington coast. The quartzitic gravels with which we are concerned in this paper, overlying the Columbia basalts in the Gorge, Bretz later correlated with the type Satsop and considered Quaternary in age.[2] The basis for the correlation of the gravels at the two localities, separated about 100 miles, seems to have been mainly lithologic similarity, particularly the presence in greater or less abundance of well-worn quartzitic pebbles of rather unique reddish color. It would seem rather unlikely, however, at the very outset that loose gravels filling a valley in essentially the present topography would be the equivalent, in time of deposition, of indurated conglomerates buried hundreds or thousands of feet beneath volcanics in a neighboring mountain range which has in post-conglomerate time been folded and trenched some thousands of feet by a stream. I. A. Williams, with whom Bretz had studied the Columbia River Gorge, accepted [1] the very late age determination for the gravels, but seemingly not without some hesitation; this apparently arose from the recognition that a Quaternary age assignment for the gravels necessitated the telescoping of an apparently long history into a surprisingly brief period of time.[2]

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[1] *Pleistocene of Western Washington* (abstract), Geol. Soc. Am. Bull., vol. 26, No. 1, 131, 1915.

[2] *The Satsop Formation of Oregon and Washington,* Jour. Geol., vol. 25, No. 5, 446, 452, 1917.

Warren D. Smith and Earl L. Packard[3] indicated that wherever they had examined the "Satsop" exposures on the Columbia and Sandy Rivers the formation appears to be an ordinary river gravel plastered against the sides of the valleys. The inference is that the Satsop is Quaternary, although no opinion is stated regarding its age.

While the writers obtained no diagnostic mammalian fossils from the "Satsop" gravels, the age determination of The Dalles formation is also determinative for the "Satsop" because of their stratigraphic relations. (*a*) Bretz considered it probable that The Dalles "is a local phase of the Satsop formation." (*b*) The Dalles beds extend far up the southeast flank of the Ortley anticline west of The Dalles. The writers found the same beds dipping northwestward on the northwest flank of the fold and overlying gravels, certainly assignable to the "Satsop." (*c*) North of the Columbia and one to two miles west of Lyle, Washington, typical quartzitic "Satsop" gravels are likewise overlain by pyroclastics and sediments, without doubt the correlative of The Dalles formation. The gravels are therefore substantially the same age, or older, than The Dalles formation. While they are stratigraphically below the latter beds, the writers did not determine whether they bear conformable or unconformable relations, but regard conformity as probable.

The palæontologic and stratigraphic evidence of the middle Neocene, rather than Quaternary, age of the "Satsop" is corroborated by other considerations.

(1) Bretz and Williams have called attention to the irregular erosion surface on the Columbia lavas, on which the beds were deposited, and the deep weathering beneath that surface. While this would doubtless require hundreds or thousands of years, it does not necessarily indicate the lapse of even a considerable fraction of a geological period. Relief of 25 to 40 feet often develops on the sur-

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[1] *The Columbia River Gorge: Its Geologic History interpreted from the Columbia River Highway,* in *Mineral Resources of Oregon,* Oregon Bureau of Mines and Geology, vol. 2, No. 3, 128, 1916.

[2] Idem, page 130.

[3] *Salient Features of the Geology of Oregon,* Jour. Geol., vol. 27, No. 2, 101, 1919.

face of a lava flow when it cools, due to movement after a thick crust has been formed; and this gives the familiar hummocky topography of recent flows. Since hundreds or even thousands of feet of rock, all of which must be weathered before it is susceptible to removal, are often eroded away in part of a geological period, as indicated at many localities in the West, it is clear that a few tens of feet of weathered basalt spell the passage of but a short time in a geologic sense. A more important feature of the basalt-gravels relationship is their approximate parallelism; the dips in the "Satsop" gravels on the flanks of the folds are in general as steep as those in the underlying Columbia basalts. While this does not demonstrate conformity, it indicates probability, in a region which tectonically has been as unstable as the West Coast during the Tertiary, that the hiatus between the two formations does not denote great lapse of time. This is particularly true because the period between the outpouring of the Columbia lavas—approximately middle Miocene—and the Quaternary, the date heretofore postulated for the deposition of the gravels, saw in the John Day region and elsewhere in the Pacific Coast states not merely one but two or more vigorous deformations.

(2) The "Satsop" conglomerate is moreover, as in the case of The Dalles formation, far too highly indurated to be Quaternary in age. In road cuts just east of Hood River this conglomerate breaks into blocks; some of the pebbles are cut through cleanly, as occurs in middle Neocene or older formations, but very seldom in younger beds.

(3) The relation in time of the "Satsop" conglomerate to gravel of true Quaternary age is also well shown at the Hood River locality. Good-sized chunks of the underlying "Satsop" conglomerate, little worn and still very compact, occur in the unconformably overlying Quaternary gravel; the superior induration and an age for the conglomerate greater than Quaternary is there very forcibly demonstrated.

(4) The writers have found the "Satsop," as Bretz reports, at various localities in the Goldendale region north of the Columbia River and across the Horseheaven plateau to the Yakima Valley. But instead of finding it lying unconformable across the edges of the Columbia basalt and the middle Neocene Ellensburg formation, the uniquely colored quartzitic conglomerate dips vertically down the steep north flank of the fold which marks the northern margin of the Horseheaven plateau. At the lower quarry on the switchbacks of the "Mabton Hill," on the Bickleton-Mabton road about ten miles south of the latter town, the conglomerate can be seen standing at

or near the base of the Ellensburg section, near the vertical Columbia basalt contact. Its induration here is like that in the Gorge.

(5) Twenty miles farther north, on Snipes Mountain west of Sunnyside, similar conglomerates are interbedded in a section without doubt referable to the Ellensburg.

Because of the considerations enumerated above the writers are convinced that the "Satsop" gravel of the Cascade Range is not Eocene or Quaternary, but middle Neocene. Since this formation is not the correlative of the Satsop of the Chehalis Valley, a new name—Hood River conglomerate—was applied to it in a preliminary statement of the results of this study. The type section is at the east end of the Columbia River Highway bridge spanning Hood River just east of the town of Hood River, Oregon.

It is quite probable that the Hood River conglomerate is a phase of The Dalles formation, as suggested by Bretz, but the conglomerate appears to be rather distinct from the volcanic series, has been and will doubtless continue to be discussed as a separate entity, is rather unique as a formation, and is believed to constitute a desirable cartographic unit for areal studies; hence the new formation name is proposed.

CORRELATION

Portland Gravels

In a paper published in 1916, Williams recognized two distinct sets of gravels in the lower Williamette Valley around Portland.[1]

Bretz, however, the following year seems to have grouped together as Satsop the unconsolidated Quaternary gravels filling the lower Willamette Valley around Portland and the Neocene indurated and deformed conglomerate, for he speaks of the "Satsop fill," indicates that most of the region is covered by Satsop, mentions that in *some places* the material is indurated to a conglomerate and sandstone, and does not allude to the presence of two sets of gravels.[2] In later papers[3] he differentiates the later gravels as the Quaternary Portland delta gravels, and indicates that they are easily distinguishable from the Satsop through their freshness.

The writers agree with Williams's and with Bretz's more recent view, of the two-fold division of the gravels in the Portland region and of the correlation of the older set with the formation which has now been termed the Hood River conglomerate lying on the Columbia basalts in the Gorge. That the Hood River is a valley fill in a relatively recent Willamette Valley is negatived by its Neocene age, its entering into the structure of the Cascades and its clear antecedence to the development of the present physiography of the region. It was deposited before the present Cascades and Willamette Valley existed; it is the Portland delta gravel and related deposits to the north and south which constitute the Quaternary valley fill.

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[1] *The Columbia Gorge: Its Geologic History interpreted from the Columbia River Highway,* in *The Mineral Resources of Oregon,* Ore. Bur. Mines and Geol., vol. 2, No. 3, 15, 1916.

[2] *The Satsop Formation of Oregon and Washington,* Jour. Geol., vol. 25, No. 5, 450, 451, 1917.

[3] *The Late Pleistocene Submergence in the Columbia Valley of Oregon and Washington,* Jour. Geol., vol. 27, No. 7, 501, 502, 1919; *The Spokane Flood beyond the Scablands,* Jour. Geol., vol. 33, No. 3, 252-257, 1925.

COLUMBIA GORGE GRAVELS

At Lyle, at the mouth of Hood River, and at other points in the Gorge are bodies of unconsolidated gravels which were deposited by the Columbia River upon substantially the present topography. They are truly Quaternary in age, as Bretz has pointed out. They are entirely distinct from the Hood River conglomerate, bearing strikingly unconformable relations to it. The contrast in physical characters also emphasizes the much greater age of the Hood River.

JOHN DAY REGION

The Mascall formation lies upon the Columbia lava and almost certainly bears conformable relations to it, but it may not be the exact correlative of the Hood River conglomerate. Its age has been considered to be middle Miocene.

Strong deformative movements had effected the Columbia lava and the Mascall before the lower Pliocene Rattlesnake formation was deposited; such angular unconformities between the Hood River and the Columbia lava are not known to exist, and it is quite certain that the Hood River is therefore older than the Rattlesnake.

RINGOLD FORMATION

In the White Bluffs of the Columbia in central Washington 500 feet of light-colored horizontal silt are exposed. The age of these beds, previously considered by several writers to be Neocene because of their supposed equivalence to the Ellensburg formation, was determined to be Pleistocene on the basis of mammalian fossils.[1] The tenor of the age determination is that the beds are older than late Pleistocene.

The Ringold is clearly distinct from, and much younger than, the Hood River conglomerate. It was in all probability laid down during the same episode of deposition which led to the formation of the unconsolidated silts and gravels near Arlington, The Dalles, and in the Columbia River Gorge, and it probably defines their age. The pre-Quaternary age of the Hood River and The Dalles formation is therewith again indicated in view of the strong unconformity separating the silts and gravels from those formations.

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[1] John C. Merriam and John P. Buwalda, *Age of Strata referred to the Ellensburg Formation in the White Bluffs of the Columbia River,* Univ. Calif. Publs., Bull. Dept. Geol., vol. 10, No. 15, 257-260, 1917.

YAKIMA REGION

In discussing the age of the Hood River conglomerate, mention was made of the scattered occurrences of the quartzitic gravel across the Horseheaven plateau and its standing at the base of the vertical Ellensburg section on the Mabton Hill. This stratigraphic relationship and the faunal evidence from the two formations indicate approximate time equivalence.

Bretz stated that the "Satsop" quartzitic gravel lies unconformably across the edges of the Ellensburg and the Yakima (Columbia) basalt in the Yakima country, central Washington.[1] The writers have not examined all the localities cited by Bretz, but they corroborate the observation that a post-Ellensburg quartzite-bearing formation exists in that region.

About one mile east of the Granger brickyards, along the railway on the south slope of Snipes Mountain, horizontal unconsolidated silt and interbedded loose gravel containing the unique red quartzite pebbles lie unconformably upon the Ellensburg beds so excellently exposed in the brickyard pits. The silt and gravel are quite certainly the Yakima valley correlative of the Quaternary Ringold formation and resulted from the same temporary relative rise of base level.

Several miles farther east, due north of the Jackson Ranch, and just west of the highest part of Snipes Mountain, a second red quartzite-bearing conglomerate, highly consolidated, is exposed in a pit on the crest of the ridge. The entire fold making Snipes Mountain is clearly seen in a cross-section of the ridge at this point, and the relations of the quartzite-bearing conglomerate indicate that it is without doubt a part of the Ellensburg section, which here consists of the usual assemblage of tuffaceous sandstone, ash, clay, gravel, and a basalt flow. The quartzite-bearing conglomerate on top of the ridge dips approximately 30° north.

In all probability the red quartzite pebbles in the younger gravel were derived from the nearby exposures of conglomerate on the hill above, for the Yakima River carries no quartzite of this type, and since the landscape on which the practically undeformed silt and gravel were deposited already closely resembled the present topography it is difficult to see how the Columbia River could have reached this area.

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[1] *The Satsop Formation of Oregon and Washington,* Jour. Geol., vol. 25, No. 5, 455, 1917.

An interesting inference arises from the fact that in central Washington quartzite-bearing conglomerate is interbedded with the andesitic sediments of the Ellensburg. It is that in middle Neocene time, after the close of the eruptions of Columbia basalt and previous to the Pliocene folding, the directions of drainage across the basalt plateau were already much like those of today, for the quartzite quite certainly came from northeastern Washington and adjoining parts of the Rocky Mountains of Idaho and British Columbia, whence the Columbia is bearing it today, while the andesitic detritus was with little doubt derived from the present site of the Cascades. The sources of the Columbia and of its tributaries lie in those same areas at present. The detailed drainage pattern was doubtless quite different, and changed continuously over the aggrading gravel plains of that period.

Methow Peneplain

Bretz states[1] that "* * * little hesitation is felt in correlating the eroded surface named the 'Methow peneplain' with the eroded surface beneath the Satsop formation in the Cascade Range." The Methow peneplain was described by Bailey Willis and George Otis Smith[2] for central Washington; it is reported to bevel both the Columbia lavas and the Ellensburg formation. In view of the apparent similarity in age of the "Satsop" (Hood River) conglomerate and the Ellensburg, it is much more probable that any erosion surface in the Cascade Range, which is the correlative of the Methow peneplain, truncates rather than lies beneath the Hood River conglomerate.

AGE OF THE CASCADE RANGE

Williams [3] and Bertz [4] regarded the Cascade Range in the Columbia Gorge region as Quaternary in age. Williams states that the "Satsop" enters into the deformation of the Cascade Range and that it appears to belong to the Pleistocene. Bretz lists the age determinations of beds at some five Pacific Coast localities with which he correlates the "Satsop" of the Gorge, and then states—"If the foregoing determinations are correct, the Cascade Range, at least in this portion, is of Quaternary age." Even if we consider that the deposition of the hundreds of feet of "Satsop" of the Gorge occurred early in the Quaternary the uplift of the Cascade Range and the cutting of the Gorge could not on this basis of reasoning have begun much before middle Quaternary time.

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[1] *The Satsop Formation of Oregon and Washington,* Jour. Geol., vol. 25, No. 5, 456, 1917.

[2] U. S. Geol. Surv. Prof. Paper 19, 1903.

[3] *The Columbia River Gorge: Its Geologic History interpreted from the Columbia River Highway,* in *The Mineral Resources of Oregon,* vol. 2, No. 3, 128-130, 1916.

[4] *The Satsop Formation of Oregon and Washington,* Jour. Geol., vol. 25, No. 5, 458, 1917.

No reason has arisen to question the essential correctness of the age determinations of the beds at different localities on the Coast with which Bretz correlates the "Satsop" of the Gorge; but the correlation is incorrect. Uplift of the range and cutting of the Gorge commenced earlier than middle Quaternary.

The age of the present range and of the present gorge as distinguished from a possible earlier range and transverse valley, which may have existed in the Gorge region in Hood River time, is rather definitely determined by the facts now available. The uplift and cutting of the present range and gorge occurred after the deposition of the Hood River conglomerate; the writers agree fully with Williams and Bretz that this formation enters into the structure of the range.

On the other hand there is reason to think that the uplift began before the deposition of at least the younger parts of the andesitic lava series known as the Cascades formation which overlies the Hood River and whose exact age is unfortunately not known to the writers. While Williams's cross-section suggests that part of this series may enter into the structure of the range he states "Contemporaneous with its progress [the uplift] the andesitic lavas came in increasing profusion." The Cascades formation is, moreover, not one which would require a long period for its accumulation; if it required part of the Pliocene for its deposition, a considerable part of upper and perhaps middle Pliocene would remain in which the uplift of the range and the cutting of the Gorge could be initiated.

That a fraction of the Pliocene as well as the Quaternary was involved in the uplift and cutting is strongly suggested by certain other evidence. Glacial deposits occupy areas in the Hood River valley, reaching well down to the Columbia River. The topography has been modified in detail since these tills were laid down, but post-uplift erosion had already sculptured the landscape, including the Gorge, to essentially its present form before their deposition. Bretz states that the lowest till is probably not attributable to the last glacial advance.[1] Apparently the task of cutting the Gorge had been essentially completed before late Pleistocene.

This conclusion is also indicated by the relation of the bodies of gravel which lie within the Gorge and which extend out of its western mouth as the Portland delta. Bretz regards these as related to the

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[1] *The Late Pleistocene Submergence in the Columbia Valley of Oregon and Washington,* Jour. Geol., vol. 27, No. 7, 495, 1919.

Spokane glaciation, and as pre-Wisconsin;[1] hence at some date before late Pleistocene time the Gorge had already assumed approximately its present form and proportions.

It might nevertheless be held that the duration of the remaining earlier portion of the Quaternary might suffice for the uplift of the Cascade Range and the cutting of the Gorge. But if the fraction of the Quaternary which has elapsed since the earlier till was deposited is roughly a quarter or a sixth of that period, which seems a reasonable estimate, the ratio of the excavation made by the Columbia and its tributaries, in pre-till time is enormously greater than four or six times the amount of post-till dissection. This would point to a requirement of more than merely the pre-till fraction of Quaternary time for the excavation of the Gorge.

The writers are therefore of the opinion that the beginning of the development of the present Cascade Range and the Columbia River Gorge occurred not in the Quaternary but in upper Pliocene time.

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[1] *The Spokane Flood beyond the Channeled Scablands,* Jour. Geol. vol. 33, No. 2, 252, 1925.

III

OREODONTS FROM THE SESPE DEPOSITS OF SOUTH MOUNTAIN, VENTURA COUNTY, CALIFORNIA.

By Chester Stock

With two plates and 2 text-figures

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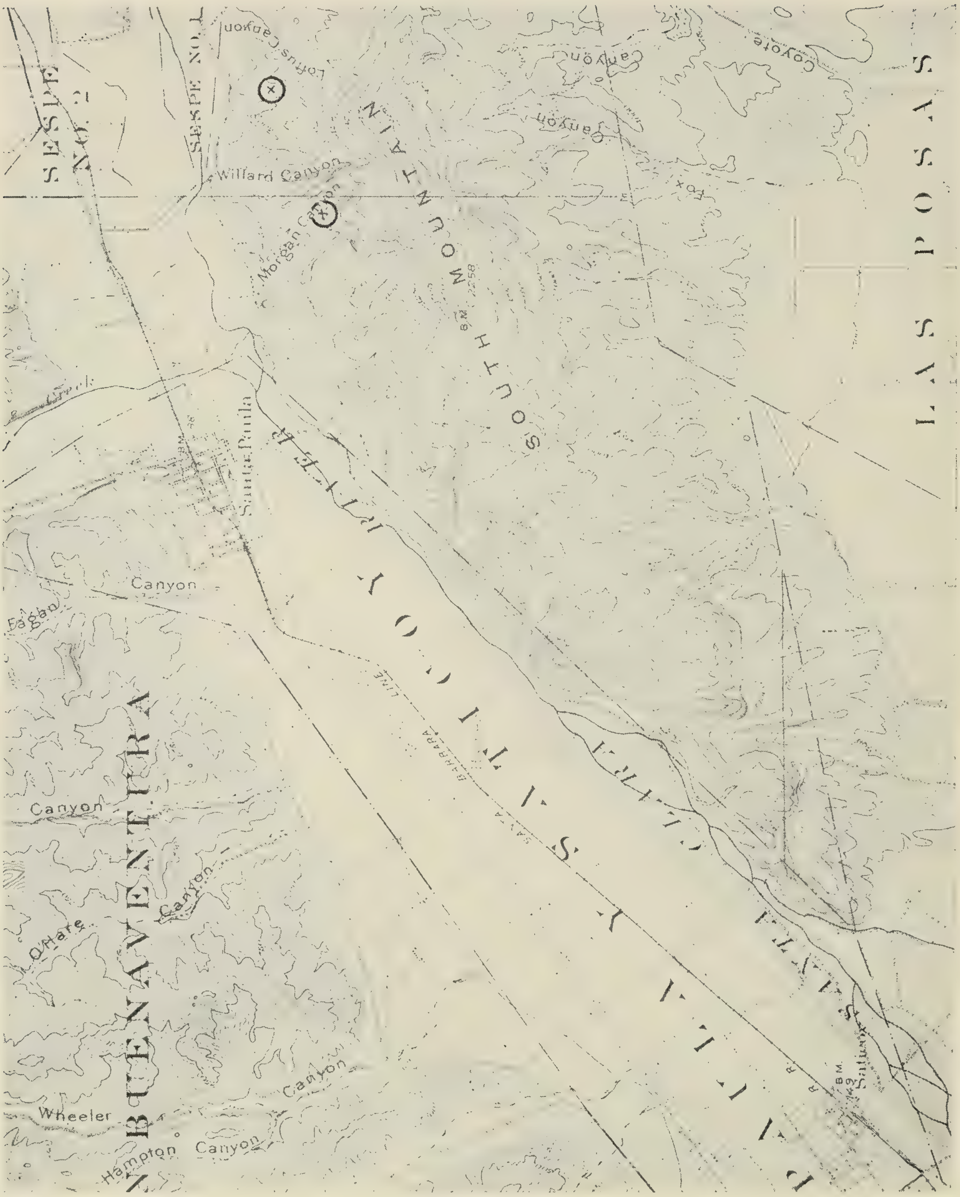

Portion of topographic map, Santa Paula Quadrangle, U. S. Geol. Surv., showing location of Sespe fossil vertebrates in the region of South Mountain, Ventura County, California.

OREODONTS FROM THE SESPE DEPOSITS OF SOUTH MOUNTAIN, VENTURA COUNTY, CALIFORNIA

INTRODUCTION

The Sespe deposits, a thick series of beds regarded as of non-marine origin, occupy a stratigraphic position in the Tertiary sequence of the Pacific Coast region between the Tejon marine Eocene and the Vaqueros marine Miocene. As mapped by W. S. W. Kew the Sespe beds are seen to possess an extensive distribution in southern California, occurring not only at the type locality on Sespe Creek, but are exposed also over broad areas along the borders of the Santa Clara Valley in Ventura County and in adjacent regions. Since their earliest study and description, these deposits have exhibited among other peculiarities an apparent absence of fossil remains. Because of the lack of palæontological materials, determination of the age of the Sespe has depended upon its stratigraphic position and upon the recognition of the faunal stages of the marine invertebrate assemblages known from deposits which immediately underlie and overlie this accumulation. Since the Tejon is generally regarded as of Upper Eocene age and the Vaqueros as belonging to the Lower Miocene, various ages ranging from Eocene to Lower Miocene have been ascribed to the Sespe. The view has also been entertained that the period of accumulation of the Sespe accounts for much of geologic time that has elapsed since the Upper Eocene and prior to the Temblor stage of the Miocene.

In recent years attention has been directed to the Sespe beds as exposed on the south side of the lower Santa Clara Valley near Santa Paula, California, as a result of the discovery of mammalian remains in these deposits by Dr. Nicolas L. Taliaferro. Following this discovery, further search in the area has brought to light additional material. The occurrence of mammalian remains is of considerable interest and importance since it affords an opportunity to present noteworthy data on the age of the Sespe and on the correlation of this accumulation with early Tertiary continental deposits of the Great Basin and Great Plains provinces.

Furthermore, the materials available represent two distinct genera of oreodonts related to *Promerycochœrus* and *Leptauchenia.* This occurrence therefore records for the first time the presence of a type allied to the former genus west of the John Day region in north-central Oregon and of a member of the *Leptauchenia-Cyclopidius* group west of the Great Plains.

OCCURRENCE

In a recent bulletin[1] on the geology and oil resources of southern California, W. S. W. Kew has discussed in detail the Sespe deposits as exposed in the region of South Mountain near Santa Paula, California. There appears to be no reason for hesitancy in the correlation of the beds called Sespe at South Mountain with the Sespe as represented at the type locality on Sespe Creek north of the Santa Clara Valley, in view of the close proximity of the two regions and in view of the similarity of the sedimentary materials of the two areas, despite the fact that there is in general a difference in type of induration of the deposits. Moreover, at the type locality the Sespe rests with apparent unconformity on the Tejon Eocene but is comformable with the overlying marine Miocene, determined as the Vaqueros horizon on the basis of invertebrate fossils. On the north side of South Mountain, south of the Santa Clara Valley, the base of the Sespe is not exposed. At the top of the section the Sespe is, however, again conformable with the marine Miocene, here also determined as the Vaqueros horizon.

A measured section of the basal portion of the Vaqueros and of the Sespe of South Mountain has been kindly furnished by Dr. N. L. Taliaferro. This is given as follows:

	Feet
Vaqueros	
Fossiliferous marine sandstone	100
Acid andesite intrusive	250
Sespe	
(1) Gray and greenish-gray sandy shale, gray sandstone, light conglomerates, red and brown sandy shale	650
(2) Finely laminated red and maroon shale, gray, green and red standstone and thin layers of algal limestones	300
(3) Gray and red sandstone with minor amounts of shale	500
(4) Red, green, gray sandstone and maroon sandy shale; a greater proportion of shale than in (3)	650
Bottom of Exposed Sespe	
(5) Lower divisions of Sespe as recognized in well borings: Alternating layers of red sandy shale, red clayey sand, blue-gray shale, and gray sandstone; logged in wells as "brown shales" but always with distinct maroon color; lower oil measures	4000±
Thickness of Sespe	6100±

The stratigraphic position of *Promerycochœrus ?* occurred within division (1) 600 to 650 feet below the top of the Sespe. The skull and jaws of the leptauchenid were found somewhat lower in the section, occurring in division (4) approximately 2000 feet below the top of the Sespe. In view of the vertical difference of approximately 1400 feet between the positions of the two oreodonts, it should be noted that the original fragments discovered by Dr. Taliaferro, and which possibly belong also to a small leptauchenid known by more complete material from the lower level, were found approximately 100 feet below the position of *Promerycochœrus ?*. Furthermore, all of the vertebrate occurrences thus far noted lie within the upper third of the entire series recognized as Sespe on the north side of South Mountain. While the recognition of more than a single faunal unit in the upper 2000 feet at this locality may not be warranted, at least on the basis of the oreodont types now known, there may in reality be recorded within this thickness a replacement of the leptauchenid by *Promerycochœrus ?*. Increased collections will doubtless reveal more clearly the Sespe mammalian succession.

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[1] W. S. W. Kew, U. S. Geol. Surv. Bull. 753, 1924.

DISCUSSION OF RELATIONSHIPS AND AGE OF UPPER SESPE OF SOUTH MOUNTAIN

Comparison of Upper Sespe with John Day and Lower Rosebud

Fortunately the two types of mammals thus far recorded from the upper Sespe of South Mountain belong to groups found elsewhere in Miocene and Oligocene assemblages. As previously mentioned the occurrence of *Promerycochœrus ?* and a leptauchenid on the Pacific Coast extends considerably the known geographic distribution of these groups of oreodonts.

In the Tertiary sequence of the John Day region of north-central Oregon the genus *Promerycochœrus* makes a sudden appearance in the upper John Day. The absence of this oreodont in the middle division of the John Day and the prevalence of the type in the upper deposits, early led Wortman to designate the latter as the *Merycochœrus (Promerycochœrus)* beds. Further palæontological explorations in this region have tended to emphasize this distinction. Curiously enough, while much intensive collecting has been conducted in the John Day, members of the *Leptauchenia-Cyclopidius* group have been conspicuously absent from the entire assemblage.

Originally regarded as Miocene by Cope, Marsh and others, the John Day on further study of its stratigraphic and faunal relationships by Merriam and by Merriam and Sinclair was referred to the upper Oligocene. In recent years the critical studies of the Tertiary formations and faunas of the John Day area, under the leadership of Dr. John C. Merriam, have served to emphasize the noteworthy differences existing between the John Day and the later Tertiary deposits and faunas in this region. The Mascall mammalian assemblage is distinctly removed from that of the John Day and is clearly much more advanced. The Mascall is currently regarded as middle Miocene in age. The disparity in age between the Mascall and John Day is further indicated by the length of time involved in the extravasation of the great Columbia lava series lying below the Mascall and by the marked hiatus separating the Columbia lavas from the John Day beneath.

The absence of representatives of the *Leptauchenia-Cyclopidius* group in the John Day fauna appears hardly to be accounted for on the basis of fortuitous collecting. Rather does it suggest, perhaps, that the distribution of these oreodonts never extended into the region of the John Day basin during the period of accumulation of the John Day deposits.

Matthew in describing the lower Rosebud fauna of South Dakota recognized its relationship to the John Day, particularly the upper division of the latter, as shown by the presence of similar types. Matthew points out that the majority of the species from the lower Rosebud and many of those from the upper Rosebud are to be referred to John Day genera. He remarks, furthermore, that whenever comparisons are made on adequately preserved material, the Rosebud species show a considerable advance beyond those in the John Day fauna. It should be stated also that the lower Rosebud assemblage includes both *Promerycochœrus* and *Leptauchenia.*

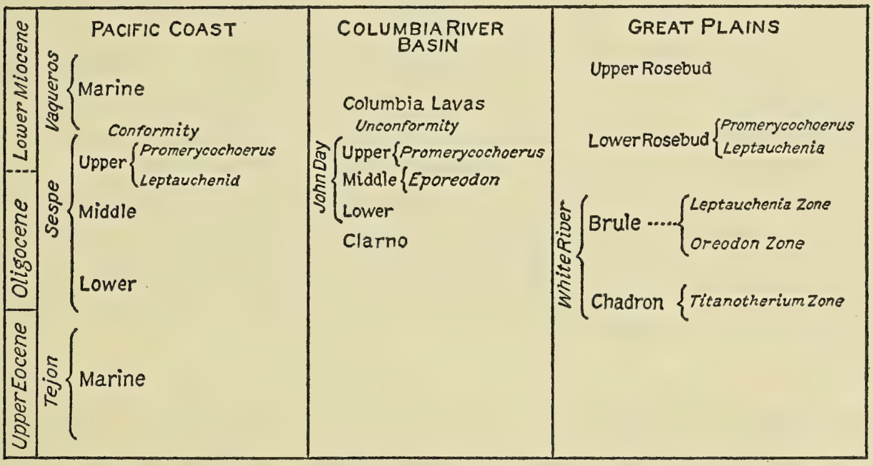
Matthew regards the lower Rosebud fauna as of lower Miocene age. While this fauna is clearly related to that of the John Day there is considerable difference in thickness of the formations in which these assemblages occur. The Great Plains deposits referred to the lower Miocene are relatively thin, although the difference in thickness of the Rosebud and John Day may be due, as Matthew suggests, to a difference in type of material accumulated and in the rapidity with which the sediments were laid down. In thickness of deposits the upper Sespe resembles more closely the John Day than the Rosebud.

The presence of *Promerycochœrus ?* and a leptauchenid in the upper Sespe suggests a correlation with the lower Rosebud. The leptauchenid occurring in the Sespe is, however, smaller than and differs in certain structural characters from any described representative of the *Leptauchenia-Cyclopidius* group from the Great Plains region. In view of the known geologic range of the group the occurrence in California would presumably not be older than upper Oligocene or younger than middle Miocene. Were the occurrence to be regarded as older than upper Oligocene it would necessitate recognition of an earlier appearance of true leptauchenids and *Promerycochœrus ?* on the Pacific Coast than elsewhere on the North American continent. The occurrence of these two types of oreodonts in a conformable series of deposits having a thickness of approximately 2000 feet suggests that the period of accumulation includes that represented by the deposits containing the lower Rosebud fauna.

In the Great Plains region the lower Rosebud appears to be stratigraphically continuous with the White River, and the beds which lie between the characteristic faunal zones of these deposits have yielded almost exclusively remains of *Leptauchenia.* A somewhat similar relationship may prevail within the upper Sespe if it is ultimately shown that the range of the leptauchenid extends from a level 2000 feet below the Vaqueros contact to a level approximately 1400 feet higher in the section and the downward range of *Promerycochœrus ?* does not extend much below its present recorded level of 600 to 650 feet below the Vaqueros.

While the large oreodont from the Sespe is presumably referable to *Promerycochœrus,* a more detailed determination of relationship of this type to the several species known from the upper John Day is difficult on the basis of the material now available. Occurrence of closely related types at the California and eastern Oregon localities is of considerable importance, particularly in view of the relatively short geologic range of the genus. Loomis[1] states that the range of *Promerycochœrus* extends from lower to middle Miocene.

The time relations of the oreodonts from the upper Sespe to those recorded from the John Day and lower Rosebud are expressed in the following table:



	PACIFIC COAST	COLUMBIA RIVER BASIN	GREAT PLAINS
Lower Miocene	Vaqueros { Marine	Columbia Lavas	Upper Rosebud
	Conformity	*Unconformity*	
	Sespe { Upper { *Promerycochoerus* *Leptauchenid*	John Day { Upper { *Promerycochoerus*	Lower Rosebud { *Promerycochoerus* *Leptauchenia*
Oligocene	Middle	Middle { *Eporeodon* Lower Clarno	White River { Brule ····· { *Leptauchenia Zone* *Oreodon Zone*
	Lower		Chadron { *Titanotherium Zone*
Upper Eocene	Tejon { Marine		

Fig. 1—Comparative table showing position of Miocene and Oligocene oreodonts in Tertiary faunal provinces of western North America.

Age Relations of Upper Sespe and Vaqueros

Determination of age of the upper Sespe is necessarily influenced by the fact that the land-laid sediments of this formation grade upward without structural break into Miocene strata recognized as the Vaqueros horizon. According to Kew,[2] the Vaqueros in the region mapped by him possesses a characteristic assemblage of marine mollusks of which the commonest type is *Turritella inezana.* On the basis of this fauna a fairly safe correlation can be made with the Vaqueros at the type locality on Vaqueros Creek, Monterey County,

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[1] F. B. Loomis, Miocene oreodonts in the American Museum, Bull. Amer. Mus. Nat. Hist., vol. 51, pages 1-37, 1924.

[2] W. S. W. Kew, *ibid.,* page 46, 1924.

California. In west coast Tertiary sequence of marine formations, the Vaqueros has been generally regarded as lower Miocene in age.

In a comprehensive review of the stratigraphic and palæontologic correlation of the Monterey series of the Coast Ranges of California with special reference to the occurrence of the Merychippus fauna of the North Coalinga region, Merriam[1] discussed the stratigraphic and faunal relationships of the Temblor and the Vaqueros horizons. Within the Temblor, which name Merriam was inclined tentatively to use for deposits containing the *Turritella ocoyana* fauna, occurs the Merychippus zone. This vertebrate assemblage was regarded as not older than the stage of the middle Miocene as represented by the Mascall and Virgin Valley faunas of the Great Basin region.

The Vaqueros fauna distinguished particularly by the marine gastropod *Turritella inezana* has been regarded by a number of investigators as distinct from the Temblor assemblage and indicative, at least in part, of an earlier stage in the Miocene. The occurrence of *Promerycochœrus ?* and a leptauchenid in beds continuous with marine strata containing the *T. inezana* fauna is strongly suggestive of a difference in age between the Vaqueros of the South Mountain region and the Temblor as recognized in the North Coalinga area. If the Merychippus zone, featured particularly by the presence of *Merychippus californicus,* approximates middle Miocene in age and if the Vaqueros is not far removed in time from the upper Sespe, then the Vaqueros certainly represents a stage distinctly older than middle Miocene. In the region mapped by Kew, the Vaqueros is followed upward by the Topanga marine formation referred to the middle Miocene and this in turn by the Modelo marine formation referred to the upper Miocene.

RELATION OF THE UPPER SESPE TO THE TECUYA

A small vertebrate fauna including a hypertragulid, a rhinoceros, and a sciurid, was described by Stock[2] from the Tecuya red beds of Tecuya Canyon, California. This assemblage was recognized as older than any Tertiary mammalian fauna described from the Coast Ranges, and related to that of the John Day and lower Rosebud. The Tecuya beds were correlated tentatively with the Sespe. Clark[3] states that beds containing a Vaqueros fauna are found immediately below the land-laid deposits, and that marine beds immediately above are believed to represent the same horizon. Clark has therefore referred the Tecuya beds to the lower Miocene.

Unfortunately a comparison of the mammals known from the Tecuya with those from South Mountain must await larger collections

[1] J. C. Merriam, Trans. Amer. Philos. Soc., vol. 22, pt. 3, n. s., pages 4-26, 1915.

[2] C. Stock, Univ. Calif. Publ., Bull. Dept. Geol., vol. 12, pages 267-276, 1920; H. W. Hoots (U. S. G. S. Bull. 812-D, p. 263, 1930) has indicated that the correct spelling of the name of these deposits is Tecuya, not Tecuja.

[3] B. L. Clark, Jour. Geol., vol. 29, pages 598-599, 1921.

from both localities. If the Tecuya beds are intercalated in the Vaqueros, their age, while possibly slightly younger than that of the upper Sespe of South Mountain, may not differ greatly from that of the latter locality.

SIGNIFICANCE OF CORRELATION OF UPPER SESPE WITH REFERENCE TO EUROPEAN TIME SCALE

A noticeable feature of the Tertiary record in the Coast Ranges of California is the total thickness of the marine formations referred to the Miocene. It is inconceivable that further shifting of position of west coast deposits situated near the boundaries of the Miocene may not occur in future, thereby making this period either more or less inclusive in so far as its stratigraphic record is concerned. While the relative length of the Miocene with reference to the entire Tertiary record as established on the Pacific Coast compares favorably with that of the European standard scale, this comparison does not apparently prohibit the inclusion of a further sedimentary record within the lower boundary of the Miocene.

Much remains to be known concerning the time relations of particular Miocene marine faunal horizons in California to those of the Old World. In recent years, however, some information has been secured which furnishes at least a suggestion as to the correlation of individual divisions of the Miocene. Thus Woodring[1] has discussed the significance of certain mollusks in the Bowden fauna of the Caribbean referable apparently to the *Turritella ocoyana* phylum of the Temblor of California. Obviously a correlation of the Bowden and the Temblor is clearly in need of further substantiation based on evidence other than that drawn from relationships within a single group of marine invertebrates. This has been fully recognized by Woodring. The Bowden stage, according to Woodring, is definitely related to the Vindobonian of Europe. The Vindobonian is regarded as middle Miocene. Since this division is followed below by the Burdigalian and the Acquitanian before the base of the Miocene is reached as at present determined, it appears possible that not only the Vaqueros but also some portion of the Sespe may be assigned to the Miocene. Matthew,[2] in discussing the problem of correlation of the Cenozoic formations of the Great Plains and particularly the European equivalents of the North American vertebrate faunal horizons, pointed out that the evidence as it appeared at that time tends to depress the North American Cenozoic column, thereby necessitating the correlation of particular zones with older European horizons than those generally accepted. If in the present instance we include a portion or all of the upper 2000 feet of Sespe occurring at

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[1] W. P. Woodring, Carnegie Inst. Wash. Pub. No. 385, pages 97-99, 1928.

[2] W. D. Matthew, Bull. Geol. Soc. Amer., vol. 35, pages 743-754, 1924.

South Mountain in the Miocene, not only is a considerable addition made to the sedimentary record of this period but the transfer would apparently tend to elevate somewhat the Vaqueros from its present position. On the other hand, the Vaqueros marine stage may be in part at least the equivalent of the upper portion of the Sespe, thus obviating the necessity for any considerable change in position in the lower Miocene.

SUMMARY STATEMENT OF AGE AND RELATIONSHIPS OF UPPER SESPE

In recapitulating, the following facts appear of special significance:

(1) Within the upper 2000 feet of the Sespe formation as exposed at South Mountain, Ventura County, California, occur two oreodont genera related to *Promerycochœrus* and *Leptauchenia.*

(2) The presence of these forms suggests a correlation of the upper Sespe deposits or at least of the uppermost division of these beds with those of the lower Rosebud of the Great Plains and with those of the upper John Day of north-central Oregon.

(3) Taking into account all evidence at present available relating to the age of the upper portion of the Sespe, the conclusion seems warranted that the period of accumulation of the deposits containing *Promerycochœrus ?* falls within the lower Miocene.

(4) The position and relationships of the upper Sespe with reference to the Vaqueros formation do not preclude the lower Miocene age of a portion of the former deposits. It follows that the change from land-laid to marine-laid sediments occurred within the Miocene rather than at the beginning of this period in the South Mountain region.

ENVIRONMENTAL CONDITIONS DURING UPPER SESPE TIME

The lithologic characters of the deposits referred to the Sespe of southern California present interesting problems relating to the conditions under which the sediments accumulated. A striking feature is a prevailing red color, although locally this may be subject to some variation. The presence of a red color has been regarded by several investigators as indicative of arid conditions during the period of deposition of the Sespe. Recently, Reed[1] has summarized all available information regarding the distribution, primary structures and physical features of the Sespe with a view to further recognition of the conditions under which the sediments were laid down. Reed concludes that the climate during Sespe time was certainly not more than semiarid and that the degree of weathering of the sediments derived from adjacent land areas suggests warmth and humidity. He remarks, furthermore, that the basin of deposition may have been less humid with possibly an alternation of wet and dry seasons.

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[1] R. D. Reed, Bull. Amer. Assoc. Petrol. Geol., vol. 13, pages 489-507, 1929.

Obviously whatever inferences may be drawn from the presence of mammals in the Sespe as to the environmental conditions under which these forms existed, their value may be augmented or diminished as the vertebrate life of the whole of Sespe time becomes more completely known. Our knowledge of the fauna is still restricted to that secured from the upper portion of the Sespe and is furthermore dependent upon two forms now extinct. The presence, however, of types similar to those associated with relatively large faunas elsewhere furnishes a basis for obtaining certain suggestions as to the conditions under which these forms existed in the Californian region.

Loomis[1] in discussing the structural features and adaptations of members of the family Oreodontidæ makes the following statement:

> Throughout the whole group there is great uniformity in the character of the dentition and the feet. There is none of the progressive adaptation and change characteristic of the grazing types, and I feel that this is probably due to a constancy in the type of food and feeding-ground. I should take the food to be leaves, seeds and fruit; and the feeding-ground the more or less wooded valleys along the streams. One feature characteristic of the group tends to confirm this, and that is the distinctness of the faunas from the different localities. The genera are widely distributed, but the species are local. It would seem that of the various river valleys each had its group of oreodonts, and, when there was a change in climate or other living conditions, the fauna of any given valley was either exterminated or replaced by a new immigration.

Loomis[2] has also remarked that the extremely light-limbed and short-headed *Leptauchenia* and *Cyclopidius* represent some special adaptation which is very difficult to interpret.

The remains of *Promerycochœrus ?* found in the upper Sespe occurred in a rather poorly consolidated, medium-grained sandstone, green in color but mottled with red. The characters possessed by this type do not exclude it from occupying an environment such as that postulated for the Oreodontidæ by Loomis. It is conceivable that *Promerycochœrus ?* frequented more or less wooded regions adjacent to stream courses in upper Sespe time. The habits and habitat of the much smaller leptauchenid still remain obscure. It may be doubted whether these mammals existed in a region characterized by a climate more severe than semiarid.

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[1] F. B. Loomis, Bull. Amer. Mus. Nat. Hist., vol. 51, page 17, 1924.

[2] F. B. Loomis, *ibid.*, pages 15 and 17, 1924.

DESCRIPTION OF MATERIAL

Leptauchenia ? (Sespia) californica n. subgen. and sp.

Type specimen—Facial and palatal portions of skull and portions of horizontal rami of lower jaw, No. 27720 Univ. Calif. Pale. Collections.

Subgeneric characters—Skull with large antorbital vacuities; nasals long and narrow; ramus of mandible relatively deep. External styles on upper molars less developed than in *Leptauchenia*. Styles on inner walls of lower molars feebly developed or absent. M$\overline{3}$ with inner wall of posterior lobe projecting but slightly past the inner wall of the middle lobe. No overlapping of inner enamel wall of middle lobe by inner wall of anterior lobe in M$\overline{3}$.

Specific character—Extremely small size, the Sespe type being considerably smaller than *Leptauchenia nitida*.

Sespia appears to belong unquestionably to the *Leptauchenia-Cyclopidius* group. This is clearly shown by the presence of a large antorbital vacuity, compressed nasals, hypsodont dentition, and by the structural characters of the premolars. The palate is relatively wide in No. 27720. In relative depth of lower jaw *Sespia* resembles *Cyclopidius*. A remarkable character is the diminutive size of this form. *Sespia* resembles in size *Oreonetes anceps* and is smaller than *Limnenetes platyceps* of the lower Oligocene.

Unfortunately in the specimen from the upper Sespe, the orbital and cranial portions of the skull are not preserved and the face has suffered some crushing. The nasals are narrow slender elements which may expand anteriorly as in *Cyclopidius*. The enlargement of the antorbital vacuity may be due in part to lack of preservation of the facial wall. The upper border of the vacuity is rather well defined by the nasal, but the remaining borders are not so clearly outlined. An antorbital foramen is situated above the anterior end of Pm$\overline{4}$.

The upper incisors are not preserved. The canines are relatively long slender teeth, slightly recurved. The cheek-teeth have extremely long crowns. The upper premolars appear to have an oblique position in the jaw as in *Leptauchenia*. In Pm$\underline{1}$, Pm$\underline{2}$ and Pm$\underline{3}$ the enamel pattern is comparatively simple, due in a measure to the worn condition of the teeth. As in *Leptauchenia* and *Cyclopidius* these teeth possess a prominent external wall of enamel and a postero-internal expansion of the tooth-crown. Loomis has remarked that the peculiar appearance of the anterior premolars in *Leptauchenia* is due to the suppression of the anterior basin.

In the molars, of which only M$\underline{1}$ and M$\underline{2}$ are present in No. 27720, the external styles are seemingly not so well developed as in *Leptauchenia decora*. Furthermore, the external enamel surfaces of the outer crescents in M$\underline{2}$ are flatter than in the latter genus. The proportions of the anterior and posterior pair of crescents in this tooth are somewhat unlike those in *Leptauchenia*.

Crowns of the lower canines and incisors are lacking. The latter teeth were presumably of minute size. Whether or not the complement of incisors consisted of three or two teeth on each side can not be satisfactorily determined because of the incomplete preservation of the alveolar border of the anterior end of the ramus. It is possible that only two incisors were present on each side of the lower jaw as in *Cyclopidius*.

P$\overline{1}$ projects distinctly above the level of the tooth-row. The enamel pattern exhibited by the occlusal surfaces of the lower premolars resembles that in *Leptauchenia*. In the posterior premolars the posterior crest is widened transversely as in the latter genus. In Pm$\overline{3}$ a slight fold is present on the inner side of the anterior crest, but no evidence of this fold remains on Pm$\overline{4}$. In *Sespia* the development of the fold is less advanced than in *L. decora.*

The inner surface of M$\overline{3}$ is flat, lacking the presence of a ridge or fold in the region between the two major lobes of this tooth. The inner wall of the posterior or third lobe projects but slightly beyond the inner wall of the middle lobe. The external crescents are rounded. The ramus appears relatively deep, more so than in *Leptauchenia.* The masseteric fossa extends forward to a point below the posterior end of M$\overline{3}$.

Sespia appears in some respects less advanced than either *Leptauchenia* or *Cyclopidius.* The Sespe form is distinctly smaller than any described species of the *Leptauchenia-Cyclopidius* group. In size of antorbital vacuity, slenderness of nasals and relative depth of lower jaw, *Sespia* may approach *Cyclopidius.* Possibly *Sespia* represents an early division of the *Leptauchenia* group tending toward *Cyclopidius.*

The writer is greatly indebted to Dr. W. J. Sinclair and to Dr. F. B. Loomis for expressions of opinion as to the relationships of the Sespe leptauchenid and for specimens of Great Plains species of *Leptauchenia* presented to the California Institute of Technology.

Measurements (in millimeters) of No. 27720 U. C. Coll.

Width measured between outer surfaces of skull above M$\underline{1}$	24.2
Width of nasals at middle (approximate)	5.
Width of palate between fourth upper premolars	12.2
Length from anterior end of Pm$\underline{1}$ to posterior end of M$\underline{2}$	28.7
Length from anterior end of Pm$\underline{1}$ to posterior end of Pm$\underline{4}$	15.6
Length from anterior end of Pm$\overline{1}$ to posterior end of M$\overline{3}$ (approximate)	36.
Length from anterior end of Pm$\overline{1}$ to posterior end of Pm$\overline{4}$	14.3
Anteroposterior diameter of M$\overline{3}$	10.7
Greatest transverse diameter of M$\overline{3}$	4.1

Promerycochœrus ? hesperus n. sp.

Type specimen—A fragmentary lower jaw, No. 27003 Univ. Calif. Pale. Coll.

The type is smaller than the species *Promerycochœrus macrostegus* and *P. superbus* from the John Day. The molar teeth lack a pronounced development of cingular cusps between the walls of the external crescents. Teeth slightly less hypsodont than in *Promerycochœrus,* in which respect No. 27003 may approach *Mesoreodon* more closely. In Pm$\overline{4}$, the internal extension of the posterior crest appears bifurcate, with a spur projecting forward and inward.

Loomis[1] in a critical examination of the structure and relationship of oreodont genera places considerable reliance on the structural characters of the premolar teeth of these forms. In view of the incompleteness of the material of the large oreodon available from the upper Sespe, determination of this type is of necessity largely dependent upon a comparison of the enamel pattern of the lower premolars. Fortunately these teeth are preserved and are in a moderate state of wear in No. 27003. Seemingly the structural features of the premolars, particularly Pm$\overline{3}$ and Pm$\overline{4}$, are sufficiently diagnostic to permit recognition of generic relationship. The Sespe species is presumably most closely related to *Promerycochœrus* and *Mesoreodon.* It is interesting to note that the former genus, according to Loomis, has a geologic range from lower to middle Miocene, while the latter form based upon the species *M. chelonyx* and *M. megalodon* occurs in the lower Miocene.

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[1] F. B. Loomis, Bull. Amer. Mus. Nat. Hist., vol. 51, pages 1-37, 1924.

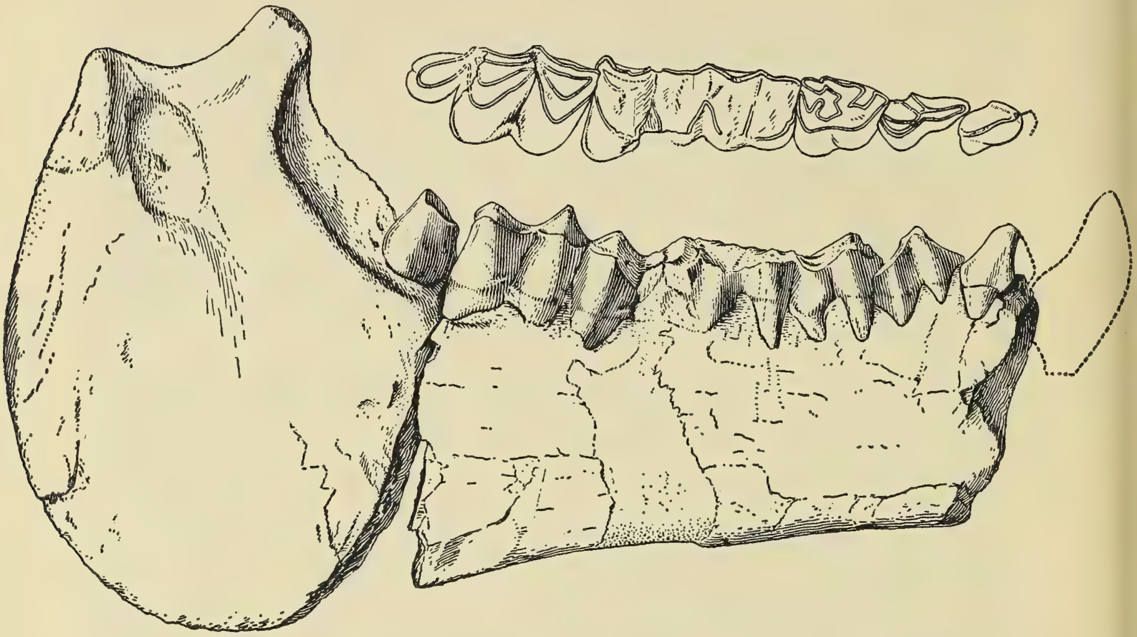

FIG. 2—*Promerycochœrus ? hesperus* n. sp. Ramus of mandible, No. 27003 U. C. Coll.; lateral view of ramus and occlusal view of teeth, x 0.50. Upper Sespe beds, South Mountain, Ventura County, California.

In the following table the characters listed in the first two columns are those given by Loomis for the genera *Mesoreodon* and *Promerycochœrus.* In the third column are given the characters of the Sespe form.

The ramus of the mandible, No. 27003 U. C. Coll., is shown in figure 3. The comparisons made in the table apparently indicate a closer resemblance between the Sespe type and *Promerycochœrus* than between the former and *Mesoreodon.* This is expressed also when the premolars are compared with the figures given by Loomis[1] for *Promerycochœrus grandis* and *Mesoreodon megalodon.*

While the condyle of the lower jaw is not completely preserved in No. 27003, the notch on the posterior rim of the vertical ramus below the condyle is apparently not so well defined as in known species of the genus. A small but relatively deep depression lies below and in front of the condyle.

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[1] F. B. Loomis, *op. cit.,* fig. 5, page 8, 1924.

Measurements (in millimeters) of No. 27003 U. C. Coll.

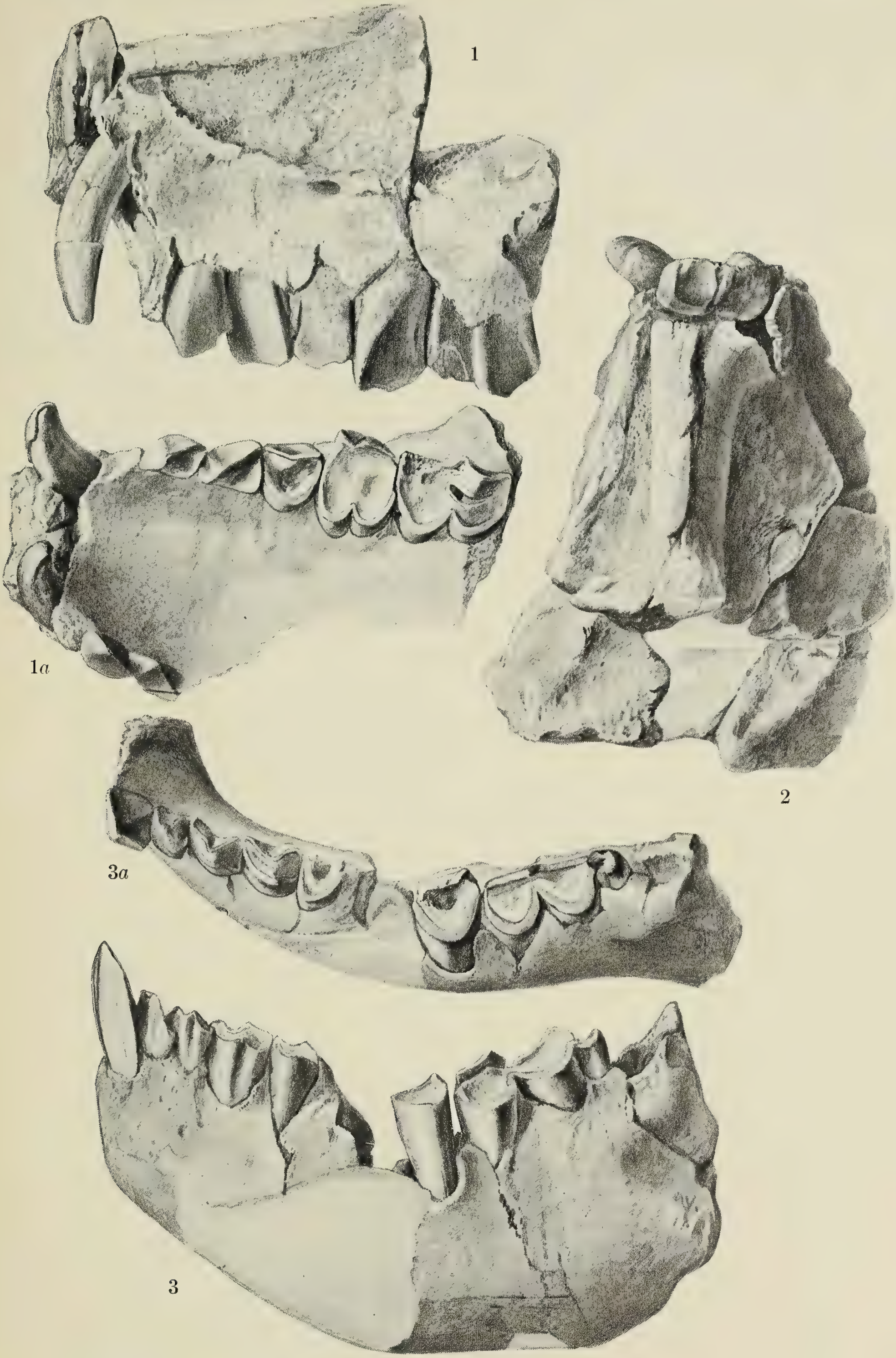
Depth of ramus from condyle to angle (approximate)	120.
Depth of ramus from top of coronoid process to angle (approximate)	122.
Depth of ramus below anterior end of M$\overline{3}$, measure normal to ventral border	45.7
Length from anterior end of Pm$\overline{1}$ to posterior end of M$\overline{3}$ (approximate)	147.6
Length from anterior end of Pm$\overline{1}$ to posterior end of Pm$\overline{4}$ (approximate)	69.3
Length from anterior end of M$\overline{1}$ to posterior end of M$\overline{3}$ (approximate)	78.3
Pm$\overline{3}$, anteroposterior diameter	18.
Pm$\overline{3}$, greatest transverse diameter	9.3
Pm$\overline{4}$, anteroposterior diameter at base of crown	19.5
Pm$\overline{4}$, greatest transverse diameter	13.5
M$\overline{3}$, anteroposterior diameter	37.6
M$\overline{3}$, greatest transverse diameter	16.9

Comparison of characters of lower premolars

Mesoreodon	Promerycochœrus	Promerycochœrus ? hesperus, n. sp.
	Lower premolars narrow and compressed.	Anterior lower premolars compressed.
Pm$\overline{3}$: Only rear portion of posterior crescent developed; united with posterior intermediate crest.	Pm$\overline{3}$: No anterior crescent. Weak posterior crescent. Posterior intermediate crest well developed; completely divides posterior basin.	Pm$\overline{3}$: No anterior crescent. Weak posterior crescent. Posterior intermediate crest extends obliquely backward and divides posterior basin.
Pm$\overline{4}$: Pillar-like cusp not so prolonged forward as in *Eporeodon,* but more distinct. Not so isolated as in *Promerycochœrus.* Intermediate crests wanting. Posterior crescent well developed and confluent with pillar-like cusp.	Pm$\overline{4}$: Pillar-like cusp at junction of posterior crescent and median crest greatly enlarged. This cusp remains distinct from crescent and crest until tooth is well worn. Enlargement developed on posterior crest like a smaller cusp.	Pm$\overline{4}$: Pillar-like median internal cusp greatly enlarged; anterior end extends well in advance of median crest. Behind median internal cusp on inner edge of tooth is a second cusp which in worn condition of crown is connected with it. Second cusp not connected with internal extension of posterior crest. Internal extension of posterior crest bifurcate with small spur projecting forward and inward.

DESCRIPTION OF LOCALITIES

Univ. Calif. Coll. Loc.	
No. 7305	NE ¼, Sec. 18, T 3 N, R 20 W, San Bernardino Base line. Occurrence in canyon locally called Gas Plant canyon. Locality N 3° E of Gas Plant and N 26° E of Santa Paula well No. 16. Lower jaw of *Promerycochœrus?* found near base of cliff in a red and green sandstone, 3 feet stratigraphically below a 6-inch cemented layer of gray sandstone.
No. A725	NE corner of SE ¼, Sec. 13, T 3 N, R 21 W, San Bernardino Base line. Occurrence in Morgan Canyon approximately 75 feet NE of South Mountain well No. 2 of Oak Ridge Oil Co., in red sandstone bank of road cut, at base of the red sandstone approximately 3 to 4 feet above level of road.



Leptauchenia ? (Sespia) californica n. subgen. and sp.

Type skull and jaw, No. 27720 U. C. Coll.; x 2.0 Fig. 1, lateral view; fig. 1*a*, ventral view; fig. 2, dorsal view of skull; figs. 3, 3*a*, lateral and dorsal views of ramus.

Upper Sespe beds, South Mountain, Ventura County, California.

IV

CARNIVORA NEW TO THE MASCALL MIOCENE FAUNA OF EASTERN OREGON

By Chester Stock

With one plate and two text-figures

CARNIVORA NEW TO THE MASCALL MIOCENE FAUNA OF EASTERN OREGON

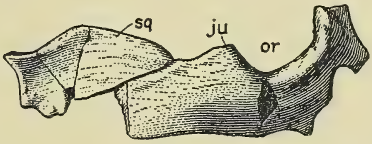
With the exception of the three species, *Tephrocyon rurestris* (Condon), *Canis* sp. and Cope's type *Lutrictis? lycopotamicus* no other carnivores have been recorded from the Mascall Miocene of the John Day Valley, Oregon, as a result of further collections obtained from these deposits since the earlier explorations in this area. During the past summer a field party from the California Institute of Technology was fortunate in securing the remains of two carnivores new to the Mascall assemblage. While the material is incomplete, records of these types are of interest and may be of significance in establishing a more accurate correlation of the Mascall fauna with Tertiary assemblages known from regions lying beyond the John Day Basin.

Leptarctus oregonensis n. sp.

Type specimen—No. 206 C.I.T. Coll. Vert. Pale. representing fragments of a skull including portions of the palate with P$\underline{4}$ and M$\underline{1}$ (Plate 1, figures 1*a*, 1*b* and text-figures 1 and 2).

Specific characters—Smaller than neotype of *Leptarctus primus*. External cingulum prominent in P$\underline{4}$ and M$\underline{1}$. Cuspule present on cingulum of M$\underline{1}$ opposite notch between paracone and metacone. Slight elevation of enamel surface posterior to protocone in M$\underline{1}$.

Locality—Exposures of Mascall deposits north of the east fork of the John Day River, approximately 1.5 miles northwest of Dayville, Oregon. Specimen collected by S. W. Lohman.



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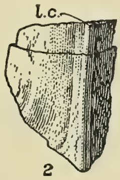

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FIG. 1—*Leptarctus oregonensis*, n. sp. Portion of right zygomatic arch, No. 206 C.I.T. Coll.; outer view; x 1.0 *or*, orbit; *ju*, jugal; *sq*, squamosal.
FIG. 2—*Leptarctus oregonensis*, n. sp. External surface of fragment of cranial wall showing portion of lateral temporal crest (*l.c.*); No. 206 C.I.T.; x 1.0.
Mascall Miocene, John Day Valley, Oregon.

Description—Reference of the Mascall specimen to the genus *Leptarctus* is clearly indicated by the superior dental formula and by the characters of P$\underline{4}$ and M$\underline{1}$. Comparison of No. 206 with the nearly complete skull described by Matthew[1] from the lower Snake Creek beds and referred to Leidy's species *L. primus* establishes the following points of similarity:

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[1] W. D. Matthew, Bull. Amer. Mus. Nat. Hist., vol. 50, pages 138-146, figs. 37-38, 1924.

(1) The superior dentition in No. 206 lacks the first premolar and the second molar.

(2) P4 possesses in addition to the paracone, metacone and protocone, a fourth cusp present on the inner side of the crown behind the protocone.

(3) M1 with well-defined paracone and metacone. Summit of protocone is continuous with a ridge which swings forward and outward along the front of the base of the paracone. Postero-internal crescent formed by hypocone.

(4) Presence of a relatively heavy zygomatic arch (fig. 1).

(5) A lateral and well-defined temporal crest is present (fig. 2).

In the Mascall specimen the two posterior teeth are completely preserved. Alveoli indicate the position of I3, C, and the two premolars. P2 and P3 were each two-rooted and appear to have been slightly more crowded than in the Snake Creek form. The anterior root socket of P2 is slightly farther behind the alveolus for the canine in the Oregon specimen than in No. 18241 Amer. Mus. from Nebraska.

P4 is very similar to the comparable tooth in Matthew's specimen. The paracone is the prominent external cusp with the shearing blade of the metacone less distinct and prominent. As noted by Matthew the notch between paracone and metacone tends to disappear in *Leptarctus*. A cingulum is present along the anterior base of the paracone. The two inner cusps are cone-shaped, the larger one being the protocone. A ledge extends from the posterior end of the hypocone to the inner posterior end of the metacone.

M1 is slightly longer than wide. An external cingulum is present, from which rises a tiny tubercle opposite the notch between paracone and metacone. An enlargement of the cingulum at the anterior end tends to form a rudimentary parastyle, while at the posterior end of the metacone is a rudimentary metastyle. The external cingulum is better defined in the Mascall specimen than in the neotype of *L. primus,* No. 18241 Amer. Mus. Coll., and there is no evidence in the latter of the tiny tubercle opposite the notch between paracone and metacone. While the small cuspule is absent in the latter, the lack of better definition of the external cingulum is possibly due to the distinctly greater wear of M1 in this form than in the Mascall type. At the posterior base of the protocone is a slight elevation of the enamel surface which crosses the valley between this cusp and the crescent-shaped hypocone. This elevation is absent in the Snake Creek specimen. In No. 206 the antero-internal end of the hypocone is continuous with a narrow cingulum which extends along the inner and anterior sides of the protocone.

Available material of the skull in No. 206 is fragmentary. The side view of the snout is shown in Plate 1, figure 1*b*. The round infra-orbital foramen is of relatively large size and the antero-external rim of this opening is situated above the anterior end of P4. A median section of the palate has been crushed inward but displays the maxillo-palatine suture. Fragments of the zygomatic process of the squamosal and of the jugal are shown in figure 1. In relative heaviness of zygomatic arch the Mascall specimen resembles closely that from the Snake Creek beds. The character of the fragment of the cranial wall shown in figure 2 clearly indicates that the temporal crest present on this piece is a portion of a lateral ridge. This ridge appears to be slightly heavier than in the neotype of *Leptarctus primus.* The presence of double temporal crests is one of the peculiar features of *Leptarctus.*

Discussion—Little can be added to the available information regarding the relationships of *Leptarctus* from a consideration of this additional material. The structure and affinities of the genus were fully reviewed by Matthew on the basis of very complete skull remains from the *Merychippus paniensis* Zone of the Snake Creek deposits. Before comparisons were made with a cast of the palate and teeth of No. 18241 Amer. Mus. Coll., the writer was impressed by greater resemblance of the Mascall specimen to the Melinæ than to the Procyonidæ. More detailed comparison has tended to substantiate Matthew's opinion of the mustelid relationships of *Leptarctus.* The presence of the type in the Mascall extends considerably the known geographic range of *Leptarctus.*

Measurements in millimeters

	Mascall No. 206	Snake Creek No. 18241
Length from anterior end of canine alveolus to posterior end of M$\underline{1}$....	25	30
P$\underline{4}$, anteroposterior diameter..........	6.2	6.7
P$\underline{4}$, transverse diameter..........	4.9	5.3
P$\underline{4}$, height of crown..........	4.1	
M$\underline{1}$, anteroposterior diameter through middle of tooth..........	6.4	7.3
M$\underline{1}$, transverse diameter..........	6.1	7

Amphicyon cf. sinapius Matthew

A fragmentary right ramus of the mandible, No. 207 Calif. Inst. Tech. Coll. Vert. Pale., Plate 1, figs. 2*a,* 2*b,* represents a large canid type found in the Mascall deposits of the John Day Valley by F. D. Bode. This specimen agrees in size and proportions with the lower jaw, No. 18258 Amer. Mus., described by Matthew [1] from the *Merychippus paniensis* Zone of the Snake Creek beds and referred to *Amphicyon sinapius.* No. 207 resembles the type of this species, No. 9358 Amer. Mus. Coll., in thickness of ramus and in size of M$\overline{1}$ and M$\overline{2}$. The cotype of *A. sinapius,* No. 9357 Amer. Mus. Coll., an unworn crown of the lower carnassial from the Pawnee Creek beds, also bears considerable similarity in size to the Mascall specimen.

No. 207 from the Mascall lacks the posterior and postero-inferior portions of the jaw and the dentition is incompletely preserved. The symphyseal area is broad and reaches back to a line descending between P$\overline{2}$ and P$\overline{3}$. A large mental foramen is situated below the anterior root of P$\overline{2}$. Its position is slightly farther posteriorly than in No. 18258. A second and much smaller foramen lies below the posterior root of P$\overline{3}$. The single incisor and canine are well worn and this type of wear characterizes also the first and second molars. Unfortunately in M$\overline{1}$ that portion of the tooth lying anterior to the heel is broken away.

The spacing of the premolars resembles that in Matthew's specimen referred to *Amphicyon sinapius.* The longest diastema between the premolars is that between P$\overline{2}$ and P$\overline{3}$. P$\overline{1}$ was perhaps a two-rooted tooth in which the roots were fused. A distinct posterior accessory cusp is in evidence in P$\overline{4}$. The heel of M$\overline{1}$ is broad with postero-external border angulate. While the heel is well worn, the surface relief of the dentine suggests the presence of a large external cusp as in amphicyonine forms.

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[1] W. D. Matthew, Bull. Amer. Mus. Nat. Hist., vol. 50, pages 104 - 111, fig. 21, 1924.

The proportions of M$\overline{2}$ appear to be similar to those in No. 18258 Amer. Mus. Coll.

Matthew has referred several specimens of the genus *Amphicyon* from the lower Snake Creek beds to *A. sinapius.* The latter species was described by Matthew [1] on the basis of a small fragment of a lower jaw with M$\overline{2}$ from the Pawnee Creek Middle Miocene of Colorado. It is a matter of some interest to record from the Mascall an amphicyonine type closely related to a species known from these Tertiary horizons of the Great Plains province.

Measurements (in millimeters) of No. 207

Length, anterior end of C to posterior end of M$\overline{2}$	170.8
Length, anterior end of P$\overline{2}$ to posterior end of M$\overline{2}$	119.3
I$\overline{3}$, transverse diameter	6.7
C, transverse diameter at base of enamel	15.4
P$\overline{2}$, anteroposterior diameter	11.6
P$\overline{2}$, transverse diameter	6.8
P$\overline{3}$, anteroposterior diameter	13.7
P$\overline{3}$, transverse diameter	7.3
P$\overline{4}$, anteroposterior diameter	19.4
P$\overline{4}$, greatest transverse diameter	10
M$\overline{1}$, anteroposterior diameter (approximate)	35
M$\overline{1}$, greatest transverse diameter of heel	16.5
M$\overline{2}$, anteroposterior diameter	25.3
Depth of jaw at posterior end of symphyseal surface	45.7
Thickness of jaw at posterior end of symphyseal surface	19.3
Length of diastema between P$\overline{2}$ and P$\overline{3}$	11.1

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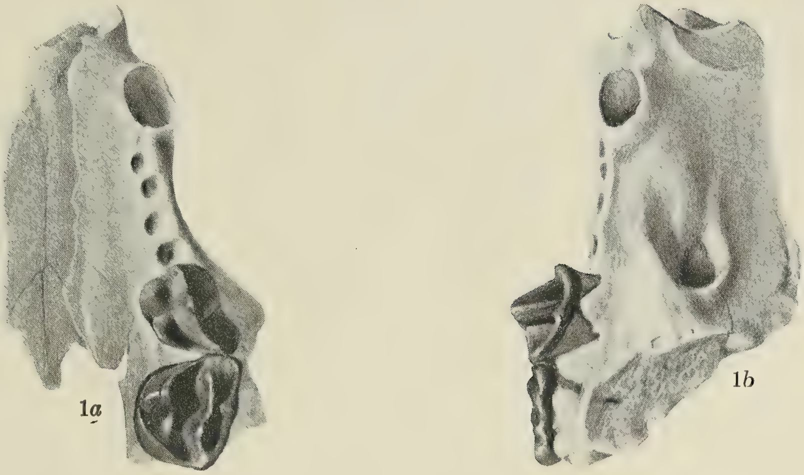
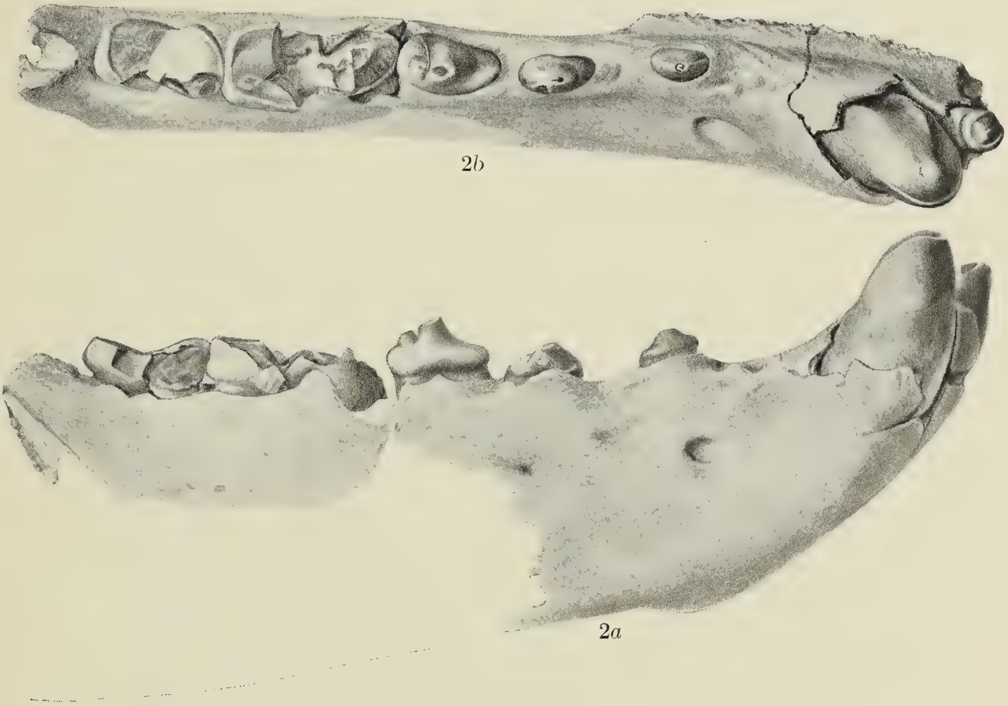
[1] W. D. Matthew, Bull. Amer. Mus. Nat. Hist., vol. 16, page 288, fig. 2, 1902.





Figs. 1*a*, 1*b*—*Leptarctus oregonensis,* n. sp. Fig. 1*a,* view of palate and occlusal view of $P\underline{4}$ and $M\underline{1}$; fig. 1*b,* lateral view; No. 206 C.I.T.; x 2.0. Mascall Miocene, John Day Valley, Oregon.

Figs. 2*a*, 2*b*—*Amphicyon* cf. *sinapius* Matthew. Lateral and occlusal views; No. 207 C.I.T.; x 0.66. Mascall Miocene, John Day Valley, Oregon.

V

CAPROMERYX MINOR TAYLOR FROM THE McKITTRICK PLEISTOCENE, CALIFORNIA

By Eustace L. Furlong

With two text-figures

CAPROMERYX MINOR TAYLOR FROM THE McKITTRICK PLEISTOCENE, CALIFORNIA

INTRODUCTION

The occurrence of a Pleistocene vertebrate fauna in an asphalt deposit near McKittrick, California, has been reported by J. C. Merriam and C. Stock. Since the publication of the provisional list of mammals from this locality, several types new to the assemblage have been discovered in the deposit. Among these should be recorded the small antilocaprid, *Capromeryx minor.* This species occurs here in association with the prong-horn antelope *Antilocapra.*

Three species of the genus *Capromeryx* are now known from the Pleistocene of North America. The type, *C. furcifer,* was described by Matthew [1] from Hay Springs, Nebraska. *C. minor* Taylor [2] occurs at Rancho La Brea, and *C. mexicana* Furlong [3] is recorded from Tequixquiac, Mexico. The occurrence of *C. minor* at McKittrick extends the range of this species during the Pleistocene from the Los Angeles basin to the Great Valley of California.

Members of the family Antilocapridæ are apparently sparsely represented in the McKittrick fauna, as only one individual of *Capromeryx* has been found, while several individuals of *Antilocapra* are known to occur.

DESCRIPTION OF MATERIAL

The specimens available from McKittrick are presumably to be referred to a single individual and include two upper and two lower molars and a calcaneum (figs. 1 and 2). A young adult animal is indicated by the material.

The dentition in specimen No. 15 Calif. Inst. Coll. Vert. Pale. exhibits a stage of wear and development of individual tooth crown comparable to that observed in *Capromeryx minor* from Rancho La Brea. The superior molars from McKittrick (fig. 1*a*) represent $M\underline{2}$ and $M\underline{3}$ detached from the left maxillary. These teeth are hypsodont with open root. In $M\underline{2}$ the parastyle and mesostyle are well developed, with the latter style somewhat more pronounced. The tooth is in an early stage of wear with anteroposterior diameter of the triturating surface relatively long. $M\underline{2}$ contracts noticeably in anteroposterior diameter from the wearing surface to the root region. The lingual wall of $M\underline{2}$ is rather sharply ridged dorsoventrally along the anterior margin, more so than in *C. mexicana,* No. 26649 Univ. Calif. Pale. Coll. The posterior pillar is not so angular as in this species and is more regularly crescentic throughout its length. M$\underline{2}$ in No. 15 from McKittrick may be one-half to two-thirds the size of the comparable tooth in *Antilocapra americana.* The grinding surface may be relatively broader than in some specimens of the modern prong-horn and the outer styles of the tooth have approximately the same position and development as in the latter.

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[1] W. D. Matthew, Bull. Amer. Mus. Nat. Hist., vol. 16, pages 317-322, 1902.

[2] W. P. Taylor, Univ. Calif. Publ. Bull. Dept. Geol., vol. 6, pages 191-197, 1911.

[3] E. L. Furlong, Univ. Calif. Publ. Bull. Dept. Geol. Sci., vol. 15, pages 137-152, 1925.

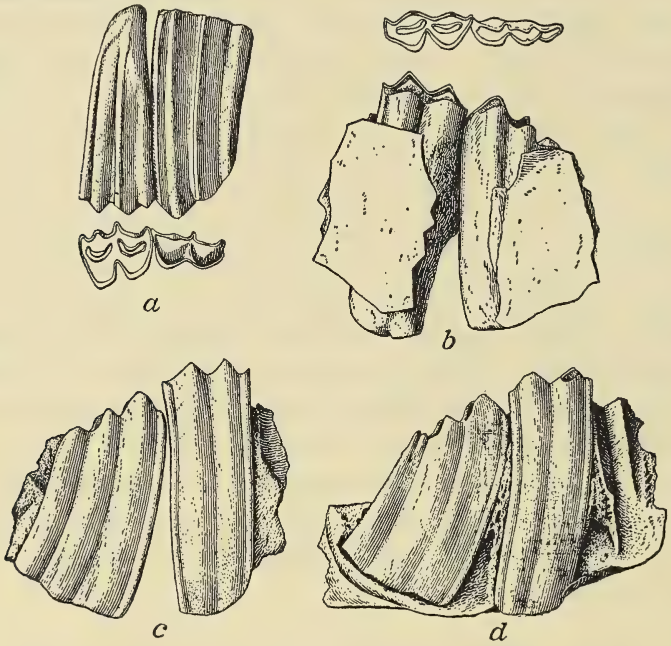

Fig. 1—*Capromeryx minor* Taylor. Upper and lower molars, x 1.0. *a,* M$\underline{2}$ and M$\underline{3}$, buccal and occlusal views; *b,* M$\overline{2}$ and M$\overline{3}$, buccal and occlusal views; *c,* M$\overline{2}$ and M$\overline{3}$, lingual view; No. 15 Calif. Inst. Tech. Coll. Vert. Pale., McKittrick Pleistocene, California. *d.* M$\overline{2}$ and M$\overline{3}$, lingual view, No. Z8501 L.A. Mus. Coll., Rancho La Brea Pleistocene, California.

In M$\underline{3}$ of specimen No. 15 the crown is unworn. This tooth is two-lobed and is broader at the open root than M$\underline{2}$. The crown is recurved posteriorly. The outer styles and the character of the inner wall do not differ materially from those in the companion tooth, M$\underline{2}$.

A fragment of the left ramus with M$\overline{2}$ and M$\overline{3}$, found associated with the upper teeth at McKittrick, is like a similar specimen No. Z8501 Los Angeles Mus. Coll. of *C. minor* from Rancho La Brea (compare figs. 1*c* and 1*d*). M$\overline{2}$ in No. 15 is very similar in stage of wear, size and character of tooth-crown to the comparable molar in the Rancho La Brea form. The styles on the lingual side are somewhat more pronounced in the former specimen. The three-lobed M$\overline{3}$ exhibits all of the characters seen in the last lower molar of *C. minor* from Rancho La Brea.

In the calcaneum of the McKittrick form (fig. 2) the epiphysis is firmly joined with the os calcis, but the suture is still distinct and indicates the youth of the animal. The articulating surfaces for the astragalus and for the fore-leg element are like those in Rancho La Brea specimens. No. 15 agrees also in size and in proportions with calcanei of *C. minor.*

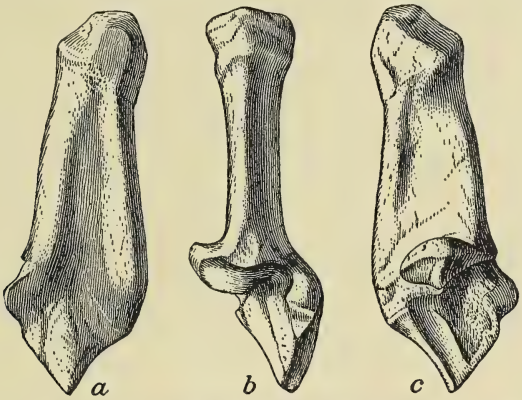

FIG. 2*a, b, c*—*Capromeryx minor* Taylor. Calcaneum; *a*, outer, *b*, anterior, and *c*, inner views; x 1.0. McKittrick Pleistocene, California.

Measurements (in millimeters) of dentition of Capromeryx minor

	McKittrick No. 15 C. I. T.	Rancho La Brea No. Z8501 L. A. Mus.
$\mathrm{M}\underline{2}$, greatest anteroposterior diameter	9.7	....
$\mathrm{M}\underline{2}$, greatest transverse diameter	7	....
$\mathrm{M}\underline{2}$, height of crown	26.4	....
$\mathrm{M}\underline{3}$, greatest anteroposterior diameter	10.4	....
$\mathrm{M}\underline{3}$, greatest transverse diameter	6.5	....
$\mathrm{M}\underline{3}$, height of crown	26.2	....
$\mathrm{M}\overline{2}$, greatest anteroposterior diameter	10.8	10
$\mathrm{M}\overline{2}$, greatest transverse diameter	4.7	4.8
$\mathrm{M}\overline{2}$, height of crown	31.7	30.3
$\mathrm{M}\overline{3}$, greatest anteroposterior diameter	13.3	12.2
$\mathrm{M}\overline{3}$, greatest transverse diameter	4.3	4.4
$\mathrm{M}\overline{3}$, height of crown	28.3	26.3

SUMMARY

A single individual of *Capromeryx* is recorded from the Pleistocene asphalt deposits of McKittrick, California. The characters of the form clearly indicate its specific identity with *C. minor* of Rancho La Brea.

Judging from the mammalian collection at present available from McKittrick, *Capromeryx* was apparently more sparsely represented in the Pleistocene assemblage than *Antilocapra.*

VI

A TERTIARY VERTEBRATE FAUNA FROM THE UPPER CUYAMA DRAINAGE BASIN, CALIFORNIA

By C. Lewis Gazin

With four plates and five text-figures

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A TERTIARY VERTEBRATE FAUNA FROM THE UPPER CUYAMA DRAINAGE BASIN, CALIFORNIA

INTRODUCTION

The discovery of Tertiary mammalian remains in the vicinity of Apache Canyon, in the upper Cuyama drainage basin, Ventura County, California, was made by Mr. John B. Stevens, geologist of the Associated Oil Company. Further collecting in this region has furnished a fauna of considerable stratigraphic and biologic significance. An investigation of the geologic features of the area and of the vertebrate collection was undertaken primarily with a view to establishing the position and relationships of the fossil assemblage in the sequence of Tertiary faunas known from the Pacific Coast and Great Basin provinces. A geologic study of the area in which the mammal-bearing beds occur and of the adjacent Lockwood Valley region to the east is still in progress.

The present study was suggested by Doctor Chester Stock, of the California Institute of Technology, to whom the author is greatly indebted for valuable advice during the progress of the investigation and patient criticism of the manuscript. The author wishes also to acknowledge the courtesy extended by Mr. Donald R. Dickey and his staff at the California Institute of Technology in allowing unreserved use of their excellent library and collection of recent mammals. The drawings were made by Mr. John L. Ridgway.

LOCATION AND PREVIOUS STUDIES OF REGION

The fossiliferous beds, indicated in figure 1, occur in the upper part of the Cuyama drainage system, west of Mount Pinos and south of the San Andreas Rift. Latitude 34° 50′ N. and longitude 119° 20′ W. intersect in a point near the vicinity of the fossil occurrences. The latter lie immediately south of the northern boundary of Ventura County, California.

During the period 1854-5, the Cuyama Valley was visited by one of the Pacific Railroad Survey parties and the geological features of the region were described by Thomas Antisell (1857, 53-57). Fairbanks (1894, 493-526) made a reconnaissance survey of the northern part of Ventura County and of several counties to the west and northwest, and later (1895, 273-300) described an analcite diabase on the northern side of Cuyama Valley. The report by A. C. Lawson (1908, 22 and 42) on the California Earthquake of 1906 includes a discussion of the principal physiographic features of the area. In the same publication Fairbanks described the San Andreas

Rift, which traverses the region to the north of the mammal-bearing beds. In studies relating to the occurrence of borax deposits, H. S. Gale (1914, 434-456) discussed the geology of the basin of Lockwood Valley immediately east of the upper Cuyama drainage. W. A. English (1916, 191-215) published a detailed description of the geology of Cuyama Valley, including a map of the formations involved in the structure of parts of both sides of the valley to the west of the fossil localities. The region north of the San Andreas Rift, in the vicinity of San Emigdio Mountain, has been described by R. W. Pack (1920, 1-179), and later by C. M. Wagner and K. H. Schilling (1923, 235-276). W. S. W. Kew (1919, 1-21) and R. N. Nelson (1925, 327-396) investigated the geology of portions of the upper Santa Ynez drainage basin lying to the southwest of Cuyama Valley.

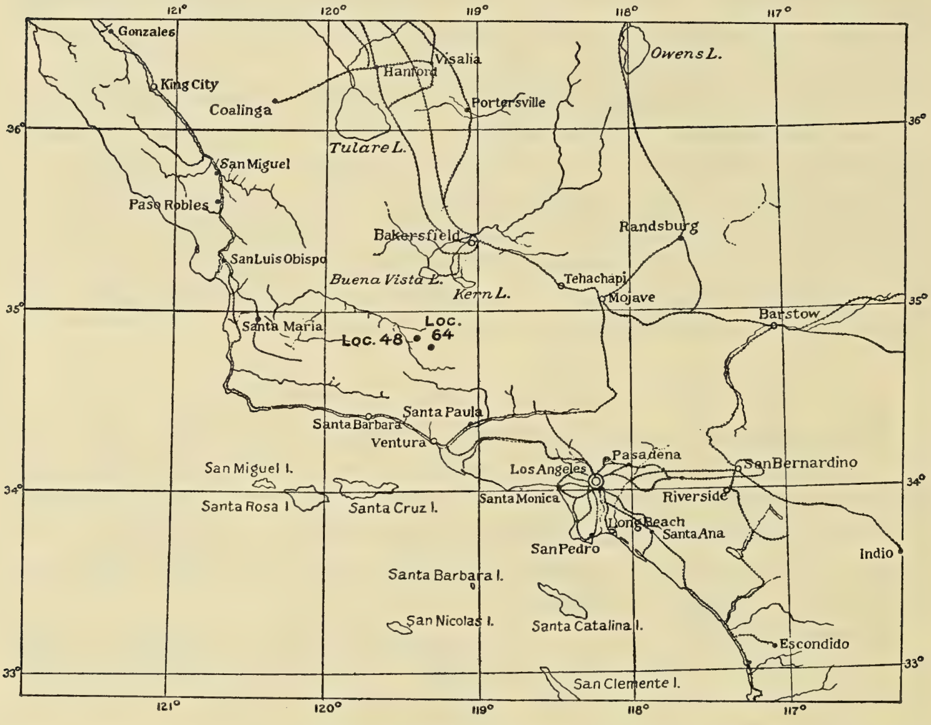

FIG. 1—Index map of a portion of southern California showing location of Cuyama Valley fossil vertebrate occurrences.

STRATIGRAPHIC SUCCESSION

The formations identified by W. A. English as occurring on the southwest side of the Cuyama Valley are as follows: (1) a series of pre-Monterey shales, (2) the Monterey group, consisting of the Maricopa and Vaqueros members, (3) the Santa Margarita sandstones and shales, (4) the Cuyama Pliocene(?), (5) the Pleistocene terrace sands and gravels, and (6) Recent alluvium. The stratigraphic succession in the vicinity of the fossil beds includes: (1) a large block of gneissoid granite to the east (Mount Pinos) with several scattered granite inliers in the sedimentary basin; (2) an extensive series of highly colored non-marine beds, considered by English as being approximately the equivalent of the Monterey; (3) the Santa Margarita(?) in the broad application of the name; and (4) Quaternary terrace and alluvial deposits.

OCCURRENCE OF FAUNA

The occurrence of Tertiary vertebrates in Apache Canyon is located approximately eight miles up this canyon, northwest of the Apache Canyon potrero. Parallel to and north of Apache Canyon is Quatal Canyon which has cut through the same horizon six or seven miles from Cuyama Valley.

The deposits in which the vertebrate fossils were found lie near the top of the formation tentatively recognized as the Monterey. The material is scattered through these upper beds from the bottom of a very conspicuous dark brown gypsiferous clay stratum to a level at least several hundred feet lower. The occurrence of fossil remains is not sharply limited to a definite horizon, but apparently becomes less frequent near the upper and lower limits of the section. The fossils are very scattered in the lowest levels exposed in the ravines adjacent to the northern portion of Apache Canyon, and the still lower horizons present in the northeastern part of Quatal Canyon have not been productive.

AGE AND RELATIONSHIPS OF THE CUYAMA FAUNA

The following is a faunal list of the types represented in the fossil collection from Cuyama Valley:

- Testudinate remains
- Avian remains
- Carnivora
    - Canid ? sp.
- Rodentia
    - Citellus (Protospermophilus) quatalensis n. subgen. and sp.
    - Perognathus furlongi n. sp.
    - Hypolagus ? apachensis n. sp.
- Proboscidea
    - Mastodont sp.
- Perissodactyla
    - Merychippus sumani Merriam
    - Protohippus sp.
    - Hipparion ? sp.
- Artiodactyla
    - Oreodont sp.
    - Camelid sp.
    - Merycodus sp.

In an attempt to reach a satisfactory age determination of the rather incomplete fauna listed above, evidence can be secured not only from a comparative study of several of the individual forms occurring in the assemblage, but also from a consideration of the stratigraphic position and structural relations of the mammal-bearing beds in the Cuyama region. It is important furthermore to recognize the relationship of the vertebrate horizon to deposits in which marine invertebrate faunas have been found.

W. A. English (1916, 191-215) correlated the Tertiary formations on the east and west sides of Cuyama Valley on the basis of regional structure. The broad portion of Cuyama Valley in which the Cuyama Ranch is located appears to be a synclinal basin, the axis of which leaves the valley on its east side between Ballinger and Quatal Canyons. The vertebrate horizon on the northeast flank of the syncline apparently occupies a stratigraphic position equivalent to that occupied by upper beds of the Monterey group on the southwest flank in Santa Barbara Canyon. In referring to the Monterey the formation containing the mammalian remains, a difficulty is encountered in that the lithology of this deposit is noticeably different from that of the Monterey on the west side of the valley. Moreover the lack of vertebrate fossils in the Monterey on the west side and the scarcity of invertebrate remains on the east side preclude the possibility of a satisfactory correlation of the two sets of beds on a basis furnished by paleontological data. Further evidence tending to support a correlation of the deposits occurring on the two sides of the valley rests on the presence of a basalt flow in the upper portion of the mammal-bearing beds as exposed north of Quatal Canyon. Basalt flows, according to English, are rather characteristic of this horizon at a number of localities, particularly in the Caliente Range to the north of Cuyama Valley where they are associated with upper beds of the Maricopa shales. It should be noted, however, that an earlier period of extrusion of perhaps Vaqueros age is recorded in the area north of Lockwood Valley, where flows are found in association with a colemanite deposit.

The following Tertiary invertebrate assemblages are recorded by English from the Cuyama region:

(1) From close to the base of the white sandstone of the Vaqueros near Santa Barbara Canyon:

Pecten magnolia
Pecten bowersi
Pecten volæformis
Turritella inezana

(2) From near the top of the Vaqueros southeast of Caliente Range:

Chione panzana
Chione n. sp., near diabloana
Mytilus mathewsoni var. expansus
Panopea estrellanus
Pecten crassicardo
Calyptræa
Murex vaquerosensis new var.
Trophosycon sp. ?
Turritella ocoyana

(3) From the upper part of the Monterey group south of Cuyama Valley:

Scutella norrisi
Chione securis
Ostrea veatchii ?
Pecten andersoni
Phacoides acutilineatus
Venus pertenuis
Turritella ocoyana

(4) From the Whiterock Bluff shale (middle) member of the Santa Margarita formation:

Astrodapsis antiselli
Astrodapsis tumidus
Ostrea titan
Pecten crassicardo
Trophon gabbianum ?
Venus pertenuis
Agasoma sinuatum
Turritella carisaensis
Turritella ocoyana new var.?
Tamiosoma gregaria

The stratigraphic position of the mammal-bearing beds appears to be approximately equivalent to the deposits from which the invertebrates given in the third list above are recorded, and occurs apparently within the limits of the range of *Turritella ocoyana.* This position would place the vertebrate stage in close time relation with the stratigraphic or faunal unit commonly called the Temblor and currently considered as middle Miocene in age. *Ostrea titan* and *Pecten crassicardo* are unfortunately the only mollusks found in the marine deposits, which English considered Santa Margarita, that overlie the mammal horizon in Quatal Canyon.

CORRELATION OF FAUNA

Pacific Coast Province

Occurrences of Miocene mammal-bearing beds in the Coast Ranges of California are apparently infrequent, due to the dominance of marine formations in this region. Extensive transgressions of the sea were presumably characteristic of this period, and it becomes apparent that in the marginal transition zones lying between the coastal province and the Great Basin, where an interfingering of terrestrial accumulations representing temporary recessions of the sea may occur, were conditions most opportune for a record of land mammals. The significance of these occurrences in Tertiary correlation studies involving the Pacific Coast and the continental region to the east has been fully appreciated.

In the Coast Ranges north of Cuyama Valley the "Big Blue" or "Rainbow" beds of the North Coalinga region (J. C. Merriam, 1915) seemingly correspond stratigraphically to the Cuyama faunal horizon, particularly with regard to its relation to the overlying "Santa Margarita." At the former locality the *Merychippus* zone lies below the "Big Blue" in beds recognized as Temblor. The mammalian fauna of the *Merychippus* zone includes relatively few forms and is chiefly characterized by the presence of *Merychippus californicus.* On the basis of evidence furnished by a comparison of the stages of development in the merychippine group, *Merychippus sumani* occurring in the Cuyama fauna appears to be somewhat more advanced than *M. californicus.* This is suggested by the greater size, heavier cementation and more prominent styles of the upper cheek-teeth in the former species. This evidence might indicate a later age for the Cuyama assemblage, but it is not conclusive, inasmuch as primitive forms may be contemporaneous with more advanced types. Certainly a consideration of the relative ages of the two horizons should take into account more than a single species. Unfortunately, in the present instance, mammalian types occurring in the one fauna are absent in the other, and this with the incomplete preservation of the materials from both horizons do not furnish an adequate basis for comparison.

Tertiary mammalian remains have been recorded by Chester Stock (1920, 267-276) from the Tecuya beds of Tecuya Canyon at the southern end of the San Joaquin Valley. It is interesting to note that the Tecuya beds are not far removed geographically from the deposits in the Cuyama region. These red beds are presumed to underlie conformably a marine series considered as the Monterey group. The fauna includes an hypertragulid, rhinoceros, and a sciurid. Although the direct comparisons which can be made between the Cuyama and Tecuya faunas are extremely limited, the presence of an hypertragulid in the latter assemblage is suggestive of an earlier stage. The difference in stratigraphic position of the two horizons with reference to the Monterey series is further evidence in support of this view.

The Mint Canyon fauna, from the Mint Canyon deposits in Los Angeles County, investigated by Mr. J. H. Maxson, is a Miocene assemblage exhibiting apparently some resemblance to the Cuyama. The following is a comparative list of the faunas from the Cuyama and Mint Canyon:

Cuyama Valley:	Mint Canyon:*
Testudinate remains	Testudinate remains
Avian remains	Avian remains
Canid ? sp.	Aelurodon sp.
Citellus (Protospermophilus) quatalensis n. subgen. and sp.	
Perognathus furlongi n. sp.	
Hypolagus ? apachensis n. sp.	Hypolagus ? apachensis
Mastodont sp.	Trilophodon sp.
	Rhinocerotid, indet.
	Parahippus (Archeohippus) near mourningi Merriam
	Merychippus sp.
Merychippus sumani Merriam	Merychippus sumani Merriam
	Merychippus (Protohippus) intermontanus Merriam
Protohippus sp.	Protohippus sp.
	Hipparion ? near mohavense callodonte Merriam
Hipparion ? sp .	Hipparion ? sp.
	Prosthennops ? sp.
	Miolabis, new form
Camelid sp.	Alticamelus ? sp.
Oreodont sp.	Oreodon, cf. Merychyus
Merycodus sp.	Merycodus near necatus
	Large Antilocaprid indet.

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* Faunal list furnished by J. H. Maxson.

The Mint Canyon beds lie stratigraphically below marine strata recognized by W. P. Woodring (1930) as being approximately equivalent to the Cierbo division of the San Pablo group. The stratigraphic positions of the Cuyama and Mint Canyon beds as at present determined do not prevent them from possessing nearly the same age. Furthermore, there prevails some faunal similarity between the two horizons. The equine species, *Merychippus sumani* Merriam, is present in both assemblages.

While the Cuyama fauna is too incompletely known to permit a satisfactory determination of exact time relationships to the Mint Canyon, it appears possible that the former is slightly older than the latter or occupies perhaps an early stage in the longer period represented by the entire Mint Canyon assemblage.

Great Basin Province

The Cuyama fauna compares most favorably with the Barstow Miocene of the better-known Tertiary faunas of the Great Basin region. All the more important larger mammals of the Cuyama fauna are known from the Barstow, although specific comparisons are not always possible. The species *Merychippus sumani* was originally described from the Barstow by J. C. Merriam. Unfortunately the rodents from the latter horizon have not been as yet fully investigated.

The Cache Peak fauna (Buwalda, 1916, 75-85) described from deposits exposed in the Tehachapi Pass region not far to the east of the Cuyama locality may be somewhat less advanced than the Cuyama fauna, and the Phillips Ranch occurrence, from which is recorded a very primitive species of *Merychippus,* is probably much earlier.

DESCRIPTION OF MATERIAL

Testudinate Remains

Tortoises are represented in the collection by a nearly complete limb bone and a number of fragments of the exoskeleton.

Avian Remains

An incomplete sacrum from the Cuyama beds has been identified by Dr. Hildegarde Howard of the Los Angeles Museum as belonging to a bird.

Carnivora

Canid ? sp.

Remains of carnivores are almost totally lacking in the Cuyama assemblage. Fragments of a right and a left ramus comprise the only material available and represent a small canid-like form, approximating the recent fox in size. The right ramus, No. 64, is without teeth. The posterior root of $P\overline{3}$, and roots of $P\overline{4}$, and the anterior part of $M\overline{1}$ are present in the jaw. Left ramus, No. 65, carries a partially preserved $P\overline{4}$ and root portions of $M\overline{1}$.

RODENTIA

Citellus (Protospermophilus) quatalensis n. subgen. and sp.

Type specimen—No. 30 C. I. T. Coll. Vert. Pale., a skull including superior dentition and lower jaw from locality 48 in Quatal Canyon, eight miles east of Cuyama Valley.

Paratypes—Left ramii, Nos. 31 and 32.

Subgeneric characters—Skull robust. Muzzle broad and vertically compressed with strong dorso-lateral ridges parallel to alveolar portion of incisors. Lower jaw shallow but strong. Superior surface of lower jaw between I and $P\overline{4}$ not greatly depressed. Upper and lower cheek teeth small, quadrate, low cusped and shallow basined. $P\underline{3}$ much reduced. Internal cusp partially divided on superior teeth. Trigonid ridge undeveloped in lower molars.

Specific characters—Superior and inferior diastemata between incisors and premolars relatively short. Palate wide in proportion to length of tooth row. Fossæ posterior to incisors and antero-lateral to anterior palatine foramina prominent. Lower tooth row long in proportion to depth of jaw. Masseteric fossa strong and terminates anteriorly beneath $M\overline{1}$. Lower teeth with postero-internal ridge terminating anteriorly in the entoconid which is disconnected from the paraconid. Very small accessory cuspule or cuspules between outer cusps on upper and lower cheek teeth.

Material—This species is represented in the collections of the California Institute by a series of eight specimens. Specimen No. 30 consists of the anterior part of the skull with the larger portion of the superior dentition and both ramii of the lower jaw which were found in immediate association with the skull. No. 34 is a more fragmentary skull than No. 30 and without teeth. Nos. 31 to 33 inclusive are lower jaw fragments carrying from two to four teeth apiece.

Description—The skull is characterized by an extremely broad muzzle with the premaxillaries forming a considerable portion of the dorsal surface well toward the anterior end. A strong dorso-lateral ridge extends parallel to the alveolar portion of the incisor from the zygoma to the nasal opening. In the living forms this ridge is not nearly so conspicuous. The width of the ventral surface of the skull is also very pronounced in the vicinity of the anterior palatine foramina. The fossæ posterior to the incisors and antero-lateral to the anterior palatine foramina are large as in many living ground squirrels. The ventro-lateral margins of the infra-orbital foramina are developed much as in Recent species referred to *Otospermophilus.*

The lower jaw has a rather short diastema between incisor and $P\overline{4}$. The superior margin of the jaw in this region is not much depressed below the level of the tooth-row. The depth of the mandible below the grinding teeth is small, this being rather characteristic of terrestrial forms and apparently an adaptive feature. The masseteric fossa is deep and the ridge along the lower margin in the anterior part is very prominent, indicating a strong masseter muscle.

$P\underline{3}$ is very small and simple, much as in *Sciurus.* In modern ground squirrels, particularly in the true citellids, this tooth is rather well developed and often bicuspid. The superior grinding teeth are quadrate in shape, rather low cusped and shallow basined as in both *Sciurus* and the otospermophilid ground squirrels, and differ somewhat in these characters from the comparable teeth in the typical citellids. Moreover, the teeth are noticeably small in proportion to the size of the skull. The posterior ridge running transversely inward from the postero-lateral cusp (metacone) in teeth present in No. 30 is formed by the metacone and protocone and a small intermediate cusp. Also, it is noticeable that one or two intermediate cusps are present on the outer rim between the paracone and metacone in several of the teeth. The most characteristic feature in the upper dentition, however, lies in the division of the internal cusp in each tooth into two equal and closely appressed cusps, adding to the rectangular appearance of the teeth. These cusps are completely united in all Recent genera. The division of the cusps is a primitive character and is commonly found in the Eocene and early Oligocene Ischyromyidæ, which family is regarded as ancestral to the Sciuridæ (W. D. Matthew, 1910, 64).

The lower teeth increase in size from $P\overline{4}$ to $M\overline{2}$ and are rudely rectangular in shape, except $P\overline{4}$ which is somewhat triangular due to the appressed character of the two anterior cusps. In this respect No. 30 corresponds more closely to *Otospermophilus* than to the typical citellids. The teeth have low, well-defined cusps and rather shallow basins. The postero-internal ridge is separated from the paraconid and carries a rather well-developed entoconid which is more like that in *Sciurus* than in any of the citellids. The paraconid is only slightly higher than the remaining, nearly equally elevated cusps, and in this respect approaches *Sciurus* and to a less extent *Otospermophilus*. The paraconid and protoconid do not tend to form a high trigonid ridge, as they do in typical *Citellus*.

Relationship—On the basis of available material, *Citellus (Protospermophilus) quatalensis* appears to resemble the Recent genus or subgenus *Otospermophilus* more nearly than it does any of the other sciurids. Moreover, the new form presents an association of primitive characters which suggests that the dentition possessed by the modern otospermophilids is more primitive than that exhibited by the typical citellids. This is also indicated by the development of the premolars which in the case of typical *Citellus* appear to have taken on more completely the characters of the molar teeth. From this consideration it seems probable that species of *Citellus* may have been derived from an *Otospermophilus*-like ancestor, probably later than the stage represented by *C. (P.) quatalensis,* assuming this form to be in or near the line of descent of the ground squirrels.

The ground squirrel stock may then have branched from the *Sciurus* line in post-Eocene time and prior to the upper Miocene. Moreover, existing groups of citellids are perhaps a result of post-Miocene specialization from a common ground-dwelling form and not in themselves culminating stages from a development along separate branches from the main sciurid stock. In arriving at this conclusion emphasis is placed particularly on the modification of the skull and lower jaw resulting from a semi-fossorial habitat. On the other hand, the dentition reflects to a certain extent the stage to which specialization has progressed in the different groups, the dentition of *Sciurus* having apparently retained the greatest association of primitive characters.

No. 30 differs from the type of *O. gidleyi,* described by Merriam, Stock and Moody (1925, 68-69) from the Rattlesnake Pliocene, in much shallower depth of mandible in proportion to length of tooth-row, in less elevation of the paraconid, and possibly in greater development of the entoconid. In dentition *O. gidleyi* is more advanced than *C. (P.) quatalensis* and shows characters closer to the modern forms.

Measurements in millimeters

	C. (P.) quatalensis	S. griseus*	O. beecheyi*	C. richardsonii*
Depth of muzzle immediately in front of maxillaries	10.3	15.6	11.3	10.0
Width of muzzle	14.7	12.7	11.6	9.9
Length of diastema between I and P$\underline{3}$	11.4	15.7	15.3	12.5
Width of palate between first molars	8.2	8.1	8.2	7.6
Length of palate from incisors to post-palatal notch	24.9	30.7	28.3	25.2
P$\underline{3}$-M$\underline{3}$, greatest length	*a* 10.5	11.6	11.2	10.6
I , anteroposterior diameter	*a* 3.4	3.6	2.8	2.0
I , transverse diameter	1.9	2.0	1.8	1.6
P$\underline{4}$, anteroposterior diameter	2.0	2.3	2.0	1.9
P$\underline{4}$, transverse diameter	2.5	2.7	2.7	2.7
M$\underline{1}$, anteroposterior diameter	2.2	2.9	2.3	2.0
M$\underline{1}$, transverse diameter	2.6	3.3	3.2	3.0
M$\underline{2}$, anteroposterior diameter	2.3	3.1	2.5	2.0
M$\underline{2}$, transverse diameter	2.7	3.6	3.2	3.0
M$\underline{3}$, anteroposterior diameter	....	3.3	2.7	2.7
M$\underline{3}$, transverse diameter	....	3.3	3.0	2.8
Depth of ramus under M$\overline{1}$	7.3	10.5	8.0	7.5
Length of diastema between I and P$\overline{4}$	6.6	8.2	9.6	8.0
P$\overline{4}$-M$\overline{3}$, greatest length	10.0	12.0	11.0	9.5
I , anteroposterior diameter	3.1	3.8	2.6	2.2
I , transverse diameter	1.6	1.4	1.6	1.5
P$\overline{4}$, anteroposterior diameter	1.9	2.2	2.1	1.9
P$\overline{4}$, transverse diameter	1.8	2.4	2.5	2.4
M$\overline{1}$, anteroposterior diameter	2.0	2.8	2.3	2.0
M$\overline{1}$, transverse diameter	2.3	3.3	3.1	2.6
M$\overline{2}$, anteroposterior diameter	2.4	3.0	2.8	2.2
M$\overline{2}$, transverse diameter	2.7	3.5	3.3	3.0
M$\overline{3}$, anteroposterior diameter	3.2	3.6	3.4	3.3
M$\overline{3}$, transverse diameter	2.7	3.2	3.1	2.8

a approximate
* Recent skulls from Donald R. Dickey Collection.

Perognathus furlongi n. sp.

Type specimen—No. 35 C. I. T. Coll. Vert. Pale., a fragmentary skull including superior dentition, from locality 64 in a ravine adjacent to Apache Canyon, eight miles northeast of Cuyama Valley.

Specific characters—Dorsal surface of the muzzle is broad with the nasofrontal suture anterior to the suture between premaxillary and frontal. Maxillary broad between the tooth-rows and diastema rather long. The tooth-row is not straight but tends to be convex outward. Teeth are convex externally in a vertical profile and the enamel is deeply infolded, slightly more so from the outer side than from the inner.

Comparison—Compared with the Recent species, *P. longimembris* and *P. californicus*, the teeth of the Cuyama form are somewhat less prismatic, each having a strongly convex external surface. The infolding of the enamel in M1 and M2 is deeper in No. 35 than in the Recent species, making due allowance for differences arising from the inequality of wear in these teeth. The fold in both M1 and M2 is impressed well through the convexity of the outer side, giving the very base of the tooth at the alveolar border an indented outline.

The paleontological record of the pocket mice is very incompletely known. Dr. L. R. Dice (1925, 125) notes the presence in the Rancho La Brea Pleistocene of forms referable to the Recent subspecies *P. californicus californicus* Merriam. Matthew (1924, 85) has described the type *Peridiomys rusticus* from the Miocene lower Snake Creek beds of Nebraska and places the genus in the family Heteromyidæ. *Peridiomys* appears to be closely related to *Perognathus* but unfortunately no comparison can be made with the Cuyama specimen, inasmuch as Matthew's description was based on a lower jaw.

Perognathus furlongi is surprisingly similar to living species of the genus, considering the wide separation in time. Although the type is somewhat more primitive in dental characters than the Recent forms, there is notable correspondence in the general appearance. This species furnishes apparently another example of the stability of structural characters exhibited by groups of rodents in their evolution during the later Cenozoic.

Measurements in millimeters of specimen No. 35

Width of muzzle dorsally	4.9
Width of palate at anterior palatine foramina	2.7
Length of diastema between incisor and P4	7.1
Depth of muzzle above median point in diastema	6.2
Width of palate between first molars	2.8
Length from anterior end of P4 to posterior end of M3	4.1
I , anteroposterior diameter	1.4
I , transverse diameter	0.9
P4, anteroposterior diameter	1.6
P4, transverse diameter	1.2
M1, anteroposterior diameter	0.9
M1, transverse diameter	1.3
M2, anteroposterior diameter	0.8
M2, transverse diameter	1.2
M3, anteroposterior diameter	0.7
M3, transverse diameter	0.9

Hypolagus ? apachensis n. sp.

Type specimen—No. 36 C. I. T. Coll. Vert. Pale., a left ramus of the mandible including inferior dentition without incisor, from locality 64 in a ravine adjacent to Apache Canyon, eight miles northeast of Cuyama Valley.

Paratype—No. 39, a maxillary fragment including P2 to M3.

Specific characters—Size smaller than in other known species referred to *Hypolagus*. Masseteric fossa weak. Anteroposterior and transverse diameters of lower molariform teeth are nearly equal. P3 is elongate anteroposteriorly with postero-external re-entrant fold simple and extending nearly halfway to internal margin, and antero-external re-entrant fold shallow and V-shaped. External surface of P3 may show one or two slight longitudinal grooves. P2 is fairly broad with one prominent and one less conspicuous anterior enamel fold.

Material—H.? apachensis is represented by approximately fifteen lower jaw fragments, retaining each from one tooth to a full set of grinding teeth. One fragment, No. 63, consists of the anterior portion of the ramus with the base of the incisor and P$\overline{3}$. In the collection are several maxillary fragments in various stages of preservation; No. 39 possesses a complete cheek-tooth series. A few incomplete limb elements are also present.

Description—Hypolagus ? apachensis compares favorably in dimensions of lower jaw, as far as known, with living species of *Sylvilagus*. Each of the lower cheek-teeth from P$\overline{4}$ to M$\overline{2}$ inclusive exhibits a fairly simple external enamel fold extending practically to the internal margin. This fold divides each tooth into two adjoining columns. The internal surface of P$\overline{3}$ may not be evenly rounded, but may have a slight yet definite groove throughout the length of the tooth. In one of the jaw fragments, No. 38, C. I. T. Coll., P$\overline{3}$ is more elongated anteroposteriorly than is the case in specimen No. 36 and shows two such flexures. M$\overline{3}$ is a double columned tooth with the fission taking place as a result of the extension of the re-entrant fold from the external surface toward the inner margin of the tooth. The masseteric fossa is apparently weak and terminates anteriorly at a point directly beneath M$\overline{3}$.

In the complete upper series, No. 39, P$\underline{2}$ is elongated laterally and shows a pronounced anterior fold with a second and incipient fold external to it. P$\underline{3}$ to M$\underline{2}$ inclusive are simple teeth with an internal, feebly crenulated re-entrant fold extending slightly past the middle of each tooth. The crenulations are not so well defined as in modern species of rabbits from California and are more like those in *H. vetus*. The external surfaces of these teeth are folded inward, but not deeply.

Comparison—The Cuyama form differs from the type species, *Hypolagus vetus* (Kellogg) (1910, 436-437, and see also L. R. Dice, 1917, 181-182) from the Thousand Creek Pliocene of Nevada in smaller size and in the character of the teeth. P$\overline{3}$ is narrower, has a less triangular shape, a more convex anterior surface, and a slightly less sharp and shallower antero-external re-entrant fold than in *H. vetus*. Usually the groove or grooves on the inner surface of this tooth are not noticeably developed in *H. vetus*, but instead this portion of the tooth is abruptly flexed, giving the triangular cross-section. P$\overline{4}$ to M$\overline{2}$ are broader anteroposteriorly in proportion to their transverse width than in *H. vetus*. Also the upper teeth have a simpler, less serate internal fold than in the type species.

H. ? apachensis differs from *H. edensis* Frick (1921, 348) of the lower Pliocene Eden beds in having a considerably shallower antero-external re-entrant fold in P$\overline{3}$ and a more posterior position of this infolding. In *H. edensis* the fold is more nearly on the anterior surface of the tooth and has in consequence changed materially the whole aspect of the tooth, giving it an appearance somewhat like that in modern forms.

The Cuyama species differs from *Lepus macrocephalus* Matthew (1907, 214-216) from the Upper Rosebud of South Dakota in possessing a larger diastema and shorter tooth row in proportion to depth of jaw. Also, *L. macrocephalus* is a distinctly larger form, although not much larger than *H. vetus*. Matthew in a later paper (1924, 86-87) refers this species and *L. primigenius* tentatively to the genus *Archæolagus*.

H. ? apachensis approaches *Archæolagus ennisianus* (Cope) (1882, 385-386; see also Dice, 1917, 180-181) in size and in weakness of the lower jaw. Although the form is close to *Archæolagus* it appears to be more advanced in most characters. P$\overline{3}$, though elongate, is not so elongate as in *A. ennisianus* and the antero-external re-entrant fold is sharp and more pronounced than in the latter type. P$\underline{2}$ has two instead of one anterior infold in *H. ? apachensis,* and the internal re-entrant fold in each of the upper molariform teeth extends beyond the middle of the tooth and possesses crenulations, which is not the case in *A. ennisianus.*

In some characters *H. ? apachensis* appears to be transitional between *A. ennisianus* and *H. vetus,* as may be inferred from the two comparisons. However, it is possible that *H.? apachensis* is not at all in the line of *Lepus* and the genus or subgenus *Hypolagus,* but rather in a more primitive line derived from *Archæolagus,* and possibly leading to such forms as *Sylvilagus* as indicated by the rather uniform small size of the jaw in *H.? apachensis.*

Measurements in millimeters

	H ? apachensis	H. vetus	H. edensis
Depth of lower jaw below P$\overline{4}$	No. 36 9.6	12.8	....
Length of diastema of lower jaw between I and P$\overline{3}$	No. 63 12.2	14.1	....
P$\underline{2}$-M$\underline{3}$, greatest length	No. 39 11.0	....	....
P$\underline{2}$, anteroposterior diameter	1.1	....	....
P$\underline{2}$, transverse diameter	2.1	....	....
P$\underline{3}$, anteroposterior diameter	1.5	....	....
P$\underline{3}$, transverse diameter	3.2	....	....
P$\underline{4}$, anteroposterior diameter	1.8	....	....
P$\underline{4}$, transverse diameter	3.0	....	....
M$\underline{1}$, anteroposterior diameter	1.7	....	....
M$\underline{1}$, transverse diameter	2.8	....	....
M$\underline{2}$, anteroposterior diameter	1.6	....	....
M$\underline{2}$, transverse diameter	2.3	....	....
M$\underline{3}$, anteroposterior diameter	1.0	....	....
M$\underline{3}$, transverse diameter	1.6	....	....
P$\overline{3}$-M$\overline{3}$, greatest length	No. 38 11.0	....	....
I , anteroposterior diameter	No. 63 1.5	1.9	....
I , transverse diameter	2.0	2.5	....
P$\overline{3}$, anteroposterior diameter	No. 36 2.3	2.9	2.4
P$\overline{3}$, transverse diameter	2.0	2.8	2.1
P$\overline{4}$, anteroposterior diameter	2.1	2.7	....
P$\overline{4}$, transverse diameter	2.2	3.2	....
M$\overline{1}$, anteroposterior diameter	2.0	2.4	2.0
M$\overline{1}$, transverse diameter	2.1	3.1	2.2
M$\overline{2}$, anteroposterior diameter	2.0	2.6	2.1
M$\overline{2}$, transverse diameter	2.1	2.8	2.2
M$\overline{3}$, anteroposterior diameter	No. 38 1.5	....	....
M$\overline{3}$, transverse diameter	1.6	....	....

PROBOSCIDEA

Several tooth fragments have been collected which undoubtedly belong to the mastodon group. The material is, however, too fragmentary to permit even a generic determination.

PERISSODACTYLA

Merychippus sumani Merriam

An incomplete upper and lower dentition, No. 41, Calif. Inst. Tech. Coll. Vert. Pale., from locality 48 in Quatal Canyon and a single upper cheektooth, No. 29, from locality 64 in Apache Canyon constitute the more important materials representing this genus and species. A number of scattered limb fragments are tentatively referred to the same type. Specimen No. 41 includes three upper cheek-teeth of the right side, a portion each of left P$\underline{4}$ and M$\underline{1}$, several lower teeth and the posterior portions of the two rami.

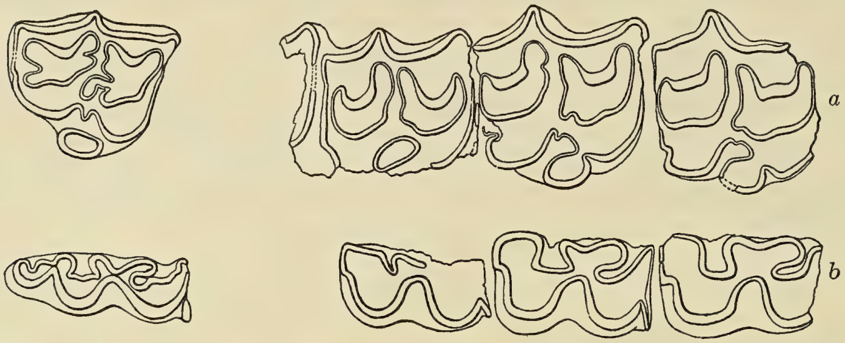


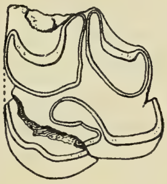
Fig. 2, *a* and *b*—*Merychippus sumani* Merriam. Superior and inferior cheek-teeth, No. 41, C.I.T. Coll.; *a,* occlusal view, P$\underline{3}$, P$\underline{4}$, M$\underline{1}$ (reversed from left side), and M$\underline{3}$; *b,* occlusal view, P$\overline{3}$, P$\overline{4}$, M$\overline{1}$ (reversed from left side), and M$\overline{3}$; x 1.0. Cuyama Valley Miocene, California.

Upper Cheek-Teeth—The upper teeth are well cemented and show a simple enamel pattern in an advanced stage of wear. The crowns of the teeth are nearly rectangular in cross-section, the anteroposterior length being slightly less than the transverse width in P$\underline{3}$, P$\underline{4}$ and M$\underline{1}$. The styles are prominent, especially the mesostyle as in the associated *Protohippus* material. The protocone is united with the protoconule in P$\underline{3}$, but completely isolated in M$\underline{3}$. P$\underline{4}$ shows a stage of wear in which the protocone has just united with the protoconule, but the isthmus is still very narrow. In M$\underline{1}$ the protocone has united with the hypocone as well as the protoconule. The hypocone is large in P$\underline{3}$ and M$\underline{1}$ with only a slight development of the posthypoconal valley. In P$\underline{4}$ the posthypoconal valley forms a somewhat deeper indentation. The fossettes are moderately broad, covering a large part of the crown area. M$\underline{3}$ shows greater relative complication of the enamel borders of the fossettes than in the preceding teeth, which is in accordance with their different crown heights.

M$\underline{3}$ exhibits a pli-caballin, a slight bifurcation of the pli-protoconule, a double pli-prefossette, and a single pli-hypostyle and pli-postfossette. In P$\underline{4}$ the pli-caballin and pli-protoconule are still prominent, but the pli-prefossette and pli-postfossette are nearly gone, and the pli-hypostyle is entirely absent. In P$\underline{3}$ and M$\underline{1}$ only a slight enamel plication exists in the region of the protoconule, representing the pli-protoconule.

Lower Cheek-Teeth—The inferior molars and premolars are relatively short anteroposteriorly and broad transversely. These teeth are well cemented and exhibit a simple enamel pattern as in the superior dentition. The protoconid and hypoconid are convex externally and the intervening enamel fold is of moderate depth, but very open. The metaconid-metastylid columns formed by an open anterior and a compressed posterior fold are strong and rounded, where wear has not proceeded too far. The groove between these two columns is particularly shallow. A prominent antero-external ridge on the protoconid is noticeable in P$\overline{4}$ and M$\overline{1}$.

Comparison—The characters exhibited by the teeth of the Quatal Canyon specimen are similar to those found in the dentition of species of *Merychippus* from the Barstow Upper Miocene. No. 41 differs from *M. californicus* Merriam of the North Coalinga Region in greater cross-section of upper teeth, and in the presence of more prominent styles and a heavier deposit of cement in these teeth. The fossette borders show a less complicated enamel pattern than in the Coalinga species. This difference prevails even when comparison is made with well-worn teeth of the latter form. The Cuyama species appears to be more advanced than *M. californicus* in size and in the presence of stronger styles and of a heavier deposit of cement in the cheek-teeth.



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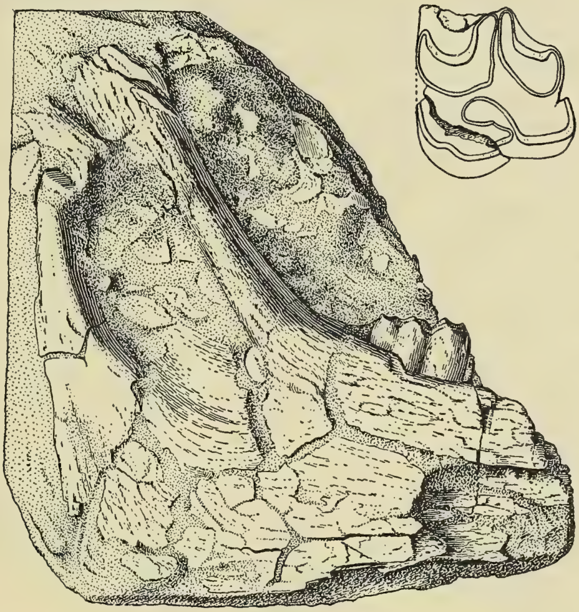

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Fig. 3—*Merychippus sumani* Merriam. Upper cheek-tooth, No. 29 C.I.T. Coll., occlusal view; x 1.0. Cuyama Valley Miocene, California.

Fig. 4—*Merychippus sumani* Merriam. Posterior portion of right ramus of mandible with $M\overline{3}$, No. 41 C.I.T. Coll., lateral view; x 0.50. Cuyama Valley Miocene, California.

Upper teeth belonging to species of *Merychippus* from the Barstow Miocene of the Mohave Desert show considerable variation in size, in complication of enamel borders of the fossettes, and in degree of union of the protocone and protoconule. Dr. J. C. Merriam (1919) recognized in the equine assemblage from this locality three distinct but apparently related merychippine species. The largest of these, *M. intermontanus,* approaches *Protohippus* in size, cementation and simplicity of enamel pattern of the teeth. A somewhat smaller form is *M. calamarius stylodontus,* approaching *M. calamarius* in size and in the proportions of the teeth but with a less complicated enamel pattern. *M. c. stylodontus* differs from *M. intermontanus* in shortness of crown, separation of protocone from protoconule for considerable length of the tooth crown, as well as in size. The third species, *M. sumani,* has smaller teeth than in *M. intermontanus* and *M. c. stylodontus* and exhibits greater complication of the enamel lake borders and more nearly complete isolation of the protocone except in very advanced stages of wear of upper cheek-teeth.

Presumably a somewhat similar example of variation in dental characters is seen in the merychippine forms recorded from the lower Snake Creek beds of Nebraska. Dr. W. D. Matthew (1924, 159 - 162) has concluded from a study of this material that a single species, *Merychippus paniensis* Cope is represented.

The Quatal Canyon specimen resembles rather closely the larger forms of *Merychippus* from the Barstow, particularly *M. calamarius stylodontus,* in simplicity of enamel pattern of the upper cheek-teeth. However, when teeth of the same stage of wear are compared, the Cuyama form is seen to resemble very closely specimen No. 21401, U. of C. Coll., referred to *M. sumani* Merriam. In the lower teeth the anteroexternal ridge of the protoconid is similar to that in *M. sumani.*

Should the several types of merychippine horses known from the Bartow be regarded as variants of a single form, as inferred by Merriam in 1915 (a, page 9; b, page 50) and as suggested by Matthew in 1924 (161-162) it may be found desirable to refer the Cuyama form to *M. calamarius sumani.*

Measurements in millimeters of dentitions of No. 41, Calif. Inst. Tech. Coll.

	Right	Left
$P\underline{3}$, anteroposterior diameter	*a*21.0	....
$P\underline{3}$, transverse diameter	23.0	....
$P\underline{4}$, anteroposterior diameter	*a*22.0	*a*20.0
$P\underline{4}$, transverse diameter	23.0	....
$M\underline{1}$, anteroposterior diameter	....	20.0
$M\underline{1}$, transverse diameter	....	....
$M\underline{3}$, anteroposterior diameter	18.5	....
$M\underline{3}$, transverse diameter	18.0	....
$P\overline{3}$, anteroposterior diameter	*a*21.0	....
$P\overline{3}$, transverse diameter	12.0	....
$P\overline{4}$, anteroposterior diameter	21.0	21.5
$P\overline{4}$, transverse diameter	11.5	12.0
$M\overline{1}$, anteroposterior diameter	....	*a*19.0
$M\overline{1}$, transverse diameter	....	9.0
$M\overline{3}$, anteroposterior diameter	23.0	....
$M\overline{3}$, transverse diameter	8.0	....

a, approximate

Protohippus sp.

The material referred to *Protohippus* includes several upper and lower teeth and a number of incomplete skeletal elements.

Unfortunately in most of the upper teeth only portions of the crowns are preserved, making specific determination difficult. These teeth resemble *Protohippus* and differ apparently from *Merychippus* in size and shape. They are characterized by a heavy deposit of cement. The limb fragments available suggest a type intermediate in size between the merychippine forms of the middle Miocene and the equid species of the Pleistocene.

The Cuyama form resembles somewhat the *P. perditus* group of the Great Plains region (Osborn, H. F., 1918, 127 -130) except for the cross-section of the upper teeth, which is somewhat larger in the former than in the latter. A rather advanced stage in the development of the protohippine horses from the Cuyama Miocene may be indicated by the size of the teeth, in which respect an approach is made to the genus *Pliohippus.*

Measurements in millimeters of the protohippine teeth

	Transverse width	Anteroposterior length	Height of crown
Left upper molar, No. 19	31	27	35
Left upper molar, No. 20	*a* 25	*a* 26	33
Left upper molar or premolar, No. 21	27 ?	29	42
Left P2 (?) No. 22	*a* 22	28	43
Right upper molar, No. 23	*a* 29	*a* 27	31
Right upper premolar, No. 25	*a* 26	29	53
Left lower tooth, No. 26	*a* 16	*a* 26	30
Right lower tooth, No. 27	12	26	45
Right lower tooth, No. 28	13	*a* 26	35

a, approximate

Hipparion ? sp.

A well-worn cheek-tooth, No. 24, from the Apache Canyon locality No. 64, exhibits characters suggestive of the genus *Hipparion.* The tooth is badly weathered, but the preserved portion of the crown exhibits a size of cross-section and a complication of the enamel pattern, particularly of the fossette borders, as in *Hipparion.*

The occurrence of the genus *Hipparion* in association with *Merychippus* is infrequent, and questionable in this case.

Measurements in millimeters of right upper cheek-tooth No. 24

Anteroposterior length	(?) 28
Transverse width	25
Height of crown	12-20

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Oreodont sp.

The presence of an oreodon in the Cuyama fauna is suggested by the posterior portion of a mandible with the roots of teeth remaining. This group of mammals may be further represented in the collection by several fragments of teeth and limb elements. The jaw fragment, No. 56, resembles in size No. 21487, U.C.C., from the Barstow, described as *Merycochœrus ? buwaldi* by J. C. Merriam. The Cuyama specimen is not generically determinable.

Camelid sp.

A fragment of the symphyseal region of a lower jaw, two astragali, and several incomplete fragments of limb elements represent the occurrence of a comparatively large camel. In so far as comparison can be made, this material corresponds favorably with comparable camel elements from the Barstow Miocene. At least two fragments of proximal phalanges suggest the presence of a smaller form related perhaps to *Procamelus.*

Merycodus sp.

The merycodont antelopes are among the more common types represented in the fauna. The material consists for the most part of scattered teeth and jaw fragments, parts of limb bones, carpal and tarsal elements, vertebræ, and many small fragments of horns. A partially complete skull, specimen No. 59, C.I.T. Coll., with the right ramus of the lower jaw and several associated parts of the skeleton belonging to the same individual were collected at locality 64 in Apache Canyon.

While the skull of this specimen is small, the individual represented is presumably not a particularly young animal for the sutures are all indistinct, the teeth well worn, and the epiphyses completely fused with the shafts in the limb bones. A noteworthy feature of this specimen is the absence of horns, for the supra-orbital portion of the surface of the frontals is quite smooth. The margin of the left orbit has been crushed and the occipital region is also damaged. The right upper tooth row is complete, but the left series is entirely missing. $M\underline{3}$ is a two-lobed tooth with a third incipient posterior lobe. $M\overline{3}$ is a simple three-lobed tooth.

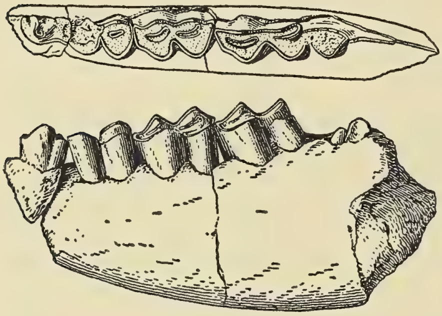

FIG. 5—*Merycodus* sp. Fragment of left ramus of mandible with $P\overline{4}$ to $M\overline{3}$ inclusive; No. 60 C.I.T. Coll.; lateral and occlusal views. x 1.0. Cuyama Valley Miocene, California.

It is difficult to reach a specific determination of the Cuyama form based on this material, inasmuch as the proportions and attitude of the horns have played a large part in distinguishing the various species described from the later Tertiary. The position of the cranial sutures and the unquestionable hypsodonty of the posterior molars in No. 59 clearly indicate an individual belonging to the merycodont group of antelopes. The absence of horns in the Cuyama specimen may perhaps be attributed to a difference in sex, but it is noteworthy that hornless forms of the genus *Merycodus* have not been found as frequently as the horned types.

The detached pieces of horn which have been found are too fragmentary to be of value in approaching a conclusion as to specific relationship. Apparently skeletal proportions are not sufficiently reliable to be of diagnostic importance as a number of the recognized species can not be distinguished safely on characters other than horn structure.

Measurements in millimeters of specimens No. 59 and No. 60.

	Specimen No. 59	Specimen No. 60
Total length of skull	*a*132	
Approximate distance between orbital rims	60	
Length of upper tooth row, $P\underline{2}$ to $M\underline{3}$ inclusive	45	
Length of lower tooth row, $P\overline{2}$ to $M\overline{3}$ inclusive	48	43 ($P\overline{4}$ to $M\overline{3}$ inclusive)
Depth of mandible below $M\overline{3}$	15	

a, approximate

LIST OF LOCALITIES

Monterey Miocene of Cuyama Valley, Ventura County, California:

Locality 48—Cliff sections and badlands in Quatal Canyon 2.5 miles east of Matthew's ranch house.
E. ½ sec. 34 and S ½ sec. 27, T. 9 N., R. 23 W., S. B. M.

Locality 64—Ravine off north side of Apache Canyon, approximately 8 miles northeast of Cuyama Valley and immediately northwest of the potrero at the head of Apache Canyon. Sec. 2 and portions of adjoining sections, T. 8 N., R. 23 W., S. B. M.
U. S. G. S. Quadrangle, Mount Pinos.

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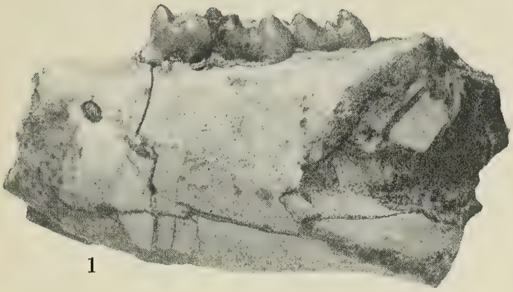

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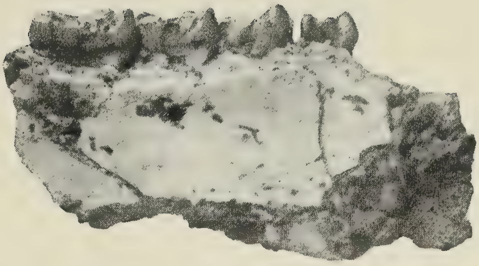

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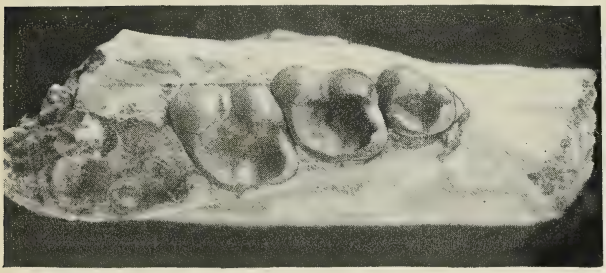

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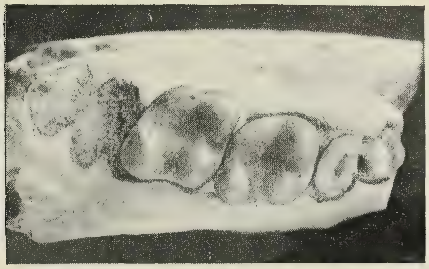

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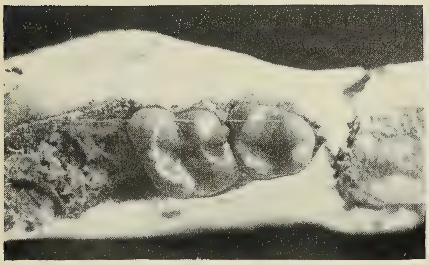

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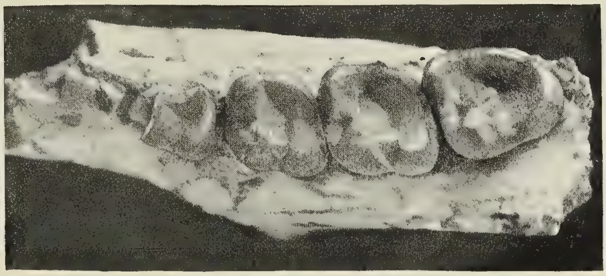

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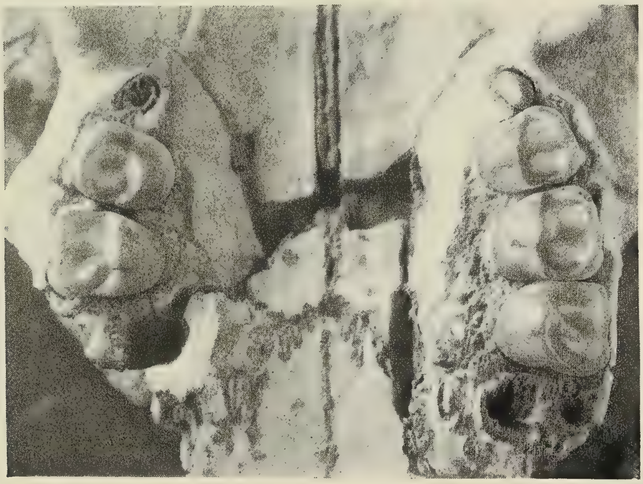

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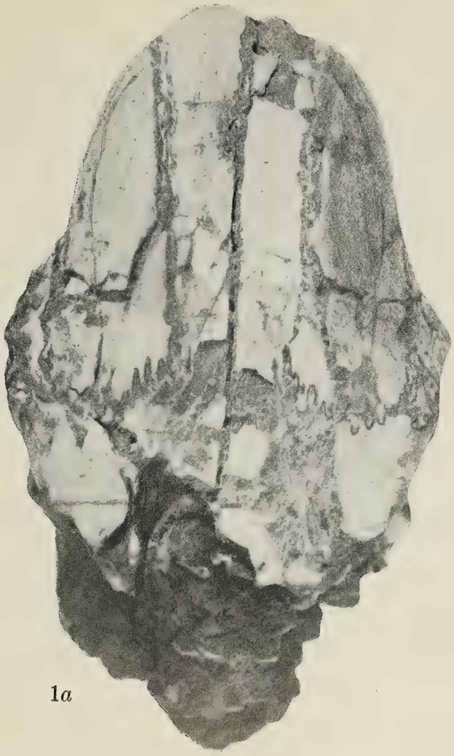
Citellus (Protospermophilus) quatalensis n. subgen. and sp.

Fig. 1, ramus of mandible, No. 31 C.I.T. Col., lateral view, x 4.0; fig. 1*a*, occlusal view, x 5.0. Fig. 2, ramus of mandible, No. 32, C.I.T. Coll., lateral view, x 4.0; 2*a*, occlusal view, x 5.0. Fig. 3, right ramus of mandible, No. 30 C.I.T. Coll., occlusal view, x 5.0. Fig. 4, left ramus of mandible, No. 30 C.I.T. Coll., occlusal view, x 5.0. Fig. 5, superior dentition, No. 30 C.I.T. Coll., occlusal view, x 5.0. Cuyama Valley Miocene, California.



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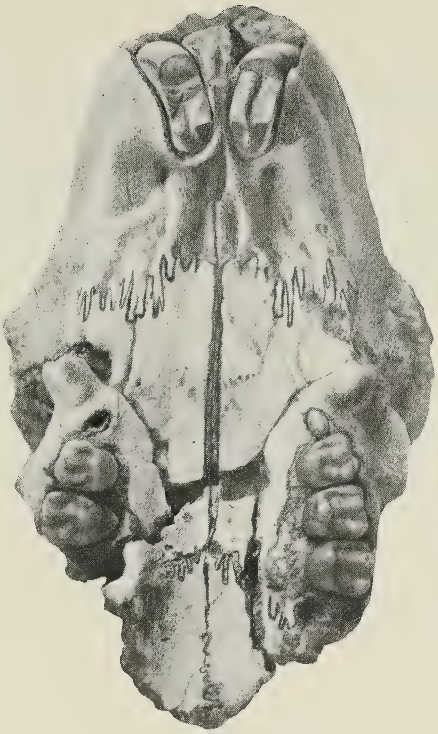

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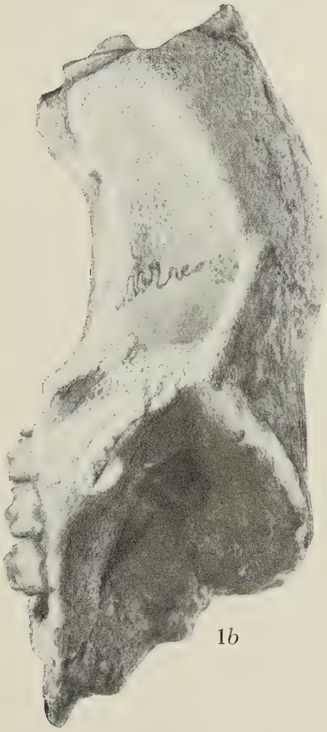

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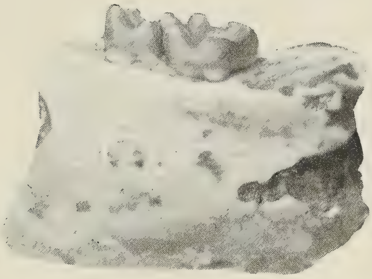

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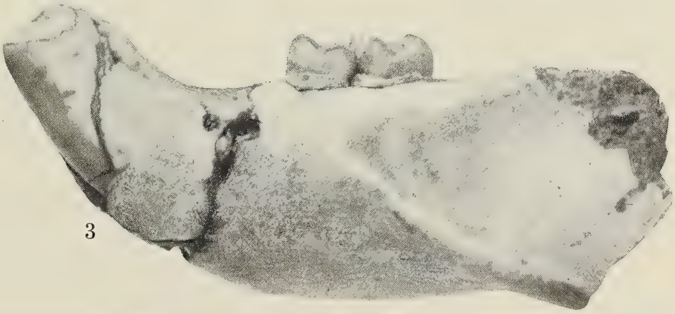

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Citellus (Protospermophilus) quatalensis n. subgen. and sp.

Figs. 1, 1*a*, 1*b*, skull, No. 30 C.I.T. Coll.; fig. 1, ventral view; fig. 1*a*, dorsal view; fig. 1*b*, lateral view; x 3.0. Fig. 2, right ramus of mandible, No. 30 C.I.T. Coll., lateral view, x 4.0. Fig. 3, left ramus of mandible, No. 30 C.I.T., lateral view, x 4.0. Cuyama Valley Miocene, California.

Hypolagus ? apachensis n. sp.

Fig. 1, maxillary fragment, No. 37 C.I.T. Coll., occlusal view, x 5.0. Fig. 2, ramus of mandible, No. 36 C.I.T. Coll., lateral view, x 4.0; fig. 2*a*, occlusal view; x 5.0. Fig. 3, $P\overline{3}$, No. 32 C.I.T. Coll., occlusal view, x 5.0. Fig. 4, ramus of mandible, No. 38 C.I.T. Coll., occlusal view, x 5.0.

Perognathus furlongi n. sp.

Figs. 5, 5*a*, skull, No. 35 C.I.T. Coll.; fig. 5, lateral view; fig. 5*a*, dorsal view; x 4.0. Fig. 6, superior dentition, No. 35 C.I.T. Coll., occlusal view, x 10.0. Cuyama Valley Miocene, California.

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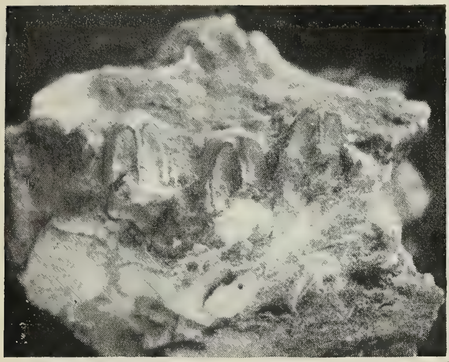

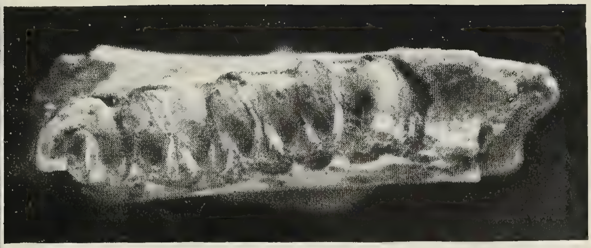

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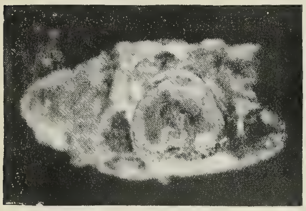

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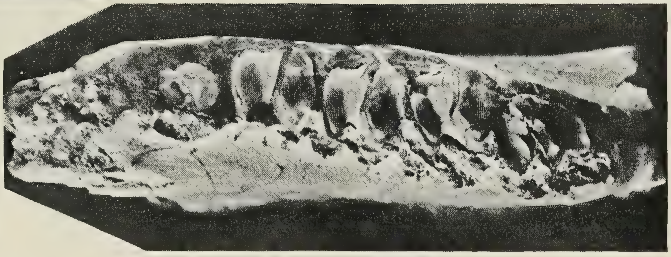

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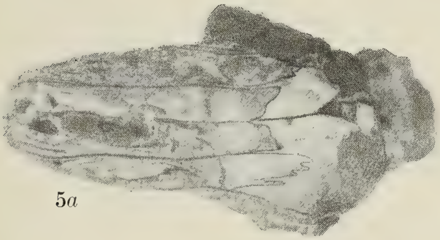

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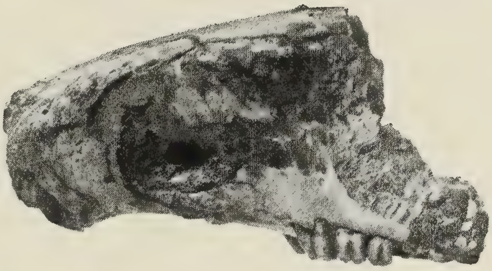

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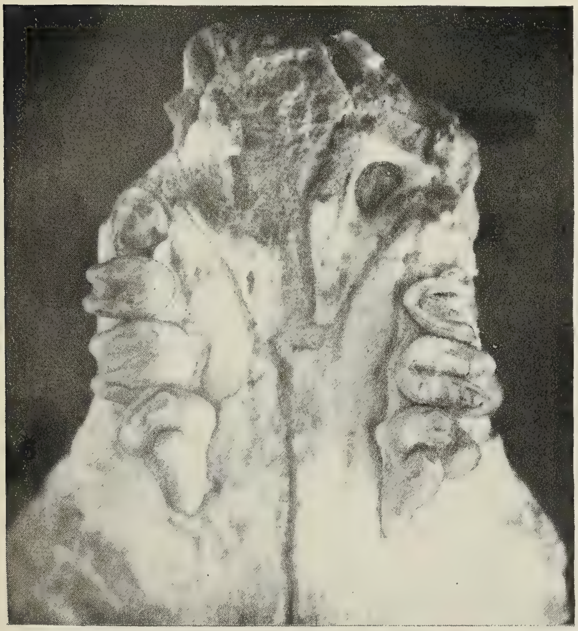

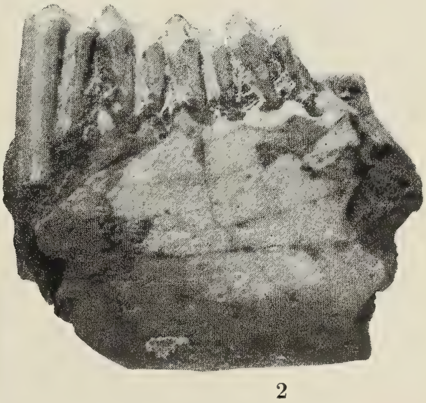

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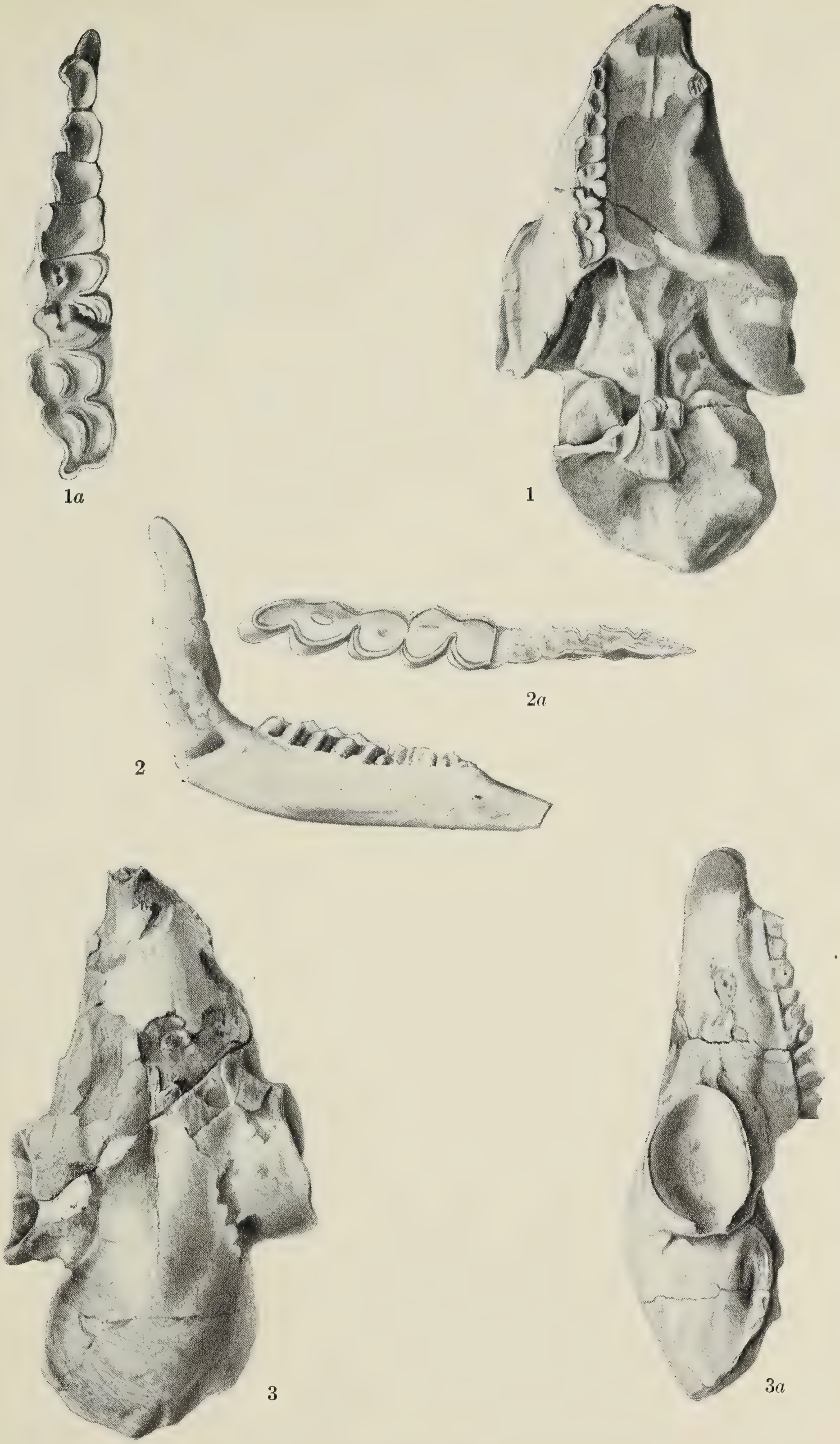

Merycodus sp.

Fig. 1, skull, No. 59 C.I.T. Coll., ventral view, x 0.66; fig. 1*a*, $P\underline{2}$ to $M\underline{3}$ inclusive, occlusal view, x 1.33. Fig. 2, ramus of mandible, No. 59 C.I.T. Coll., lateral view, x 0.66; fig. 2*a*, $P\overline{2}$ to $M\overline{3}$ inclusive, occlusal view, x 1.33. Figs. 3, 3*a*, skull, No. 59 C.I.T. Coll.; fig. 3, dorsal view; fig. 3*a*, lateral view; x 0.66. Cuyama Valley Miocene, California.

VII

A TERTIARY MAMMALIAN FAUNA FROM THE MINT CANYON FORMATION OF SOUTHERN CALIFORNIA

By John H. Maxson

With eighteen text-figures

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A TERTIARY MAMMALIAN FAUNA FROM THE MINT CANYON FORMATION OF SOUTHERN CALIFORNIA

INTRODUCTION

The Mint Canyon beds, typically exposed in Mint Canyon, seven miles northeast of Saugus, California, were described by Dr. W. S. W. Kew in Bulletin 753 (1924) of the United States Geological Survey. In 1919 during the course of geologic mapping of this region by Kew, fossil vertebrate remains were found at several localities. A provisional list of the vertebrates represented in the collection made at that time by Dr. Kew and by Dr. Chester Stock was recorded in Bulletin 753. However, no detailed study of the material was made. Further mammalian remains were secured from the Mint Canyon formation by Mr. J. W. Mitchell, Mr. Thomas Clements, Mr. H. J. Buddenhagen, by the Los Angeles Museum, and by the writer.

In view of the position of the Mint Canyon beds, immediately below a series of marine formations of the Pacific Coast Marine Province, the terrestrial fauna secured from these deposits is not only important in establishing the age of the Mint Canyon but also furnishes a basis for a comparison of the Tertiary record of this region with that of the Great Basin to the east. Opportunities to correlate the Tertiary record of the marginal marine province with the terrestrial record of the Great Basin on the basis of land vertebrates are infrequent and warrant in the present instance a careful survey of the Mint Canyon fauna.

ACKNOWLEDGMENTS

The writer wishes to acknowledge his indebtedness to those who have assisted in the collection of the material. Prof. W. D. Matthew of the Department of Paleontology, University of California, has kindly loaned for study the original collection from the Mint Canyon beds. Especially does the writer wish to thank Prof. Chester Stock of the California Institute of Technology for criticism and assistance during the course of this study. The illustrations were prepared by Mr. John L. Ridgway.

LOCATION, RELATIONSHIPS AND PHYSICAL FEATURES OF MINT CANYON FORMATION

The fossiliferous Mint Canyon formation is exposed over an extensive area located in the northern part of the Fernando Quadrangle and in the southeastern part of the Tejon Quadrangle, Los Angeles County, California. These quadrangles cover portions of the hilly country between Liebre Mountain on the northwest and the San Gabriel Mountains on the southeast. Mint Canyon is located on the north side of the Santa Clara Valley about halfway between the Los Angeles Basin and the Mohave Desert (see figure 1).

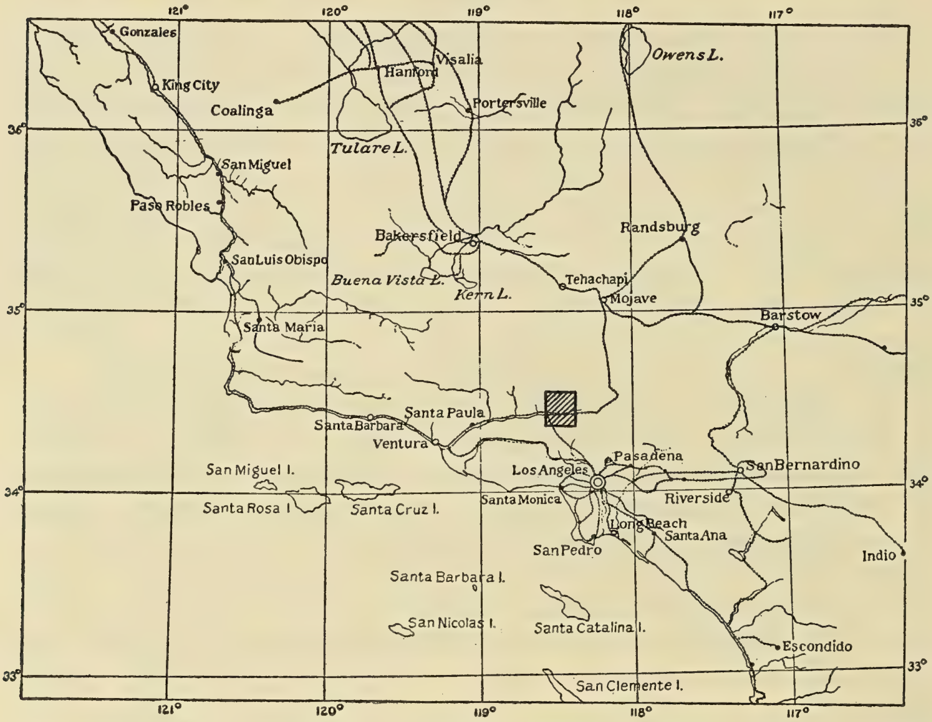

FIG. 1—Index map of portion of southern California showing location (shaded quadrangle) of Mint Canyon deposits.

The general geologic relationships of the Mint Canyon formation have been fully discussed by Dr. W. S. W. Kew. The observations recorded by Kew have been of considerable value to the writer during field work in this region.

The Mint Canyon deposits overlie unconformably the Sespe ? formation (upper Oligocene or lower Miocene). The latter beds tentatively assigned by Kew to the Sespe are not fossiliferous but have been correlated on the basis of lithology and stratigraphic position. Overlying the Mint Canyon formation with angular discordance is a marine formation referred by Kew[1] questionably to the Modelo. Recent studies of an invertebrate fauna from this formation have led Dr. W. P. Woodring[2] to state: "Rather poorly preserved specimens of *Astrodapsis* from this locality closely resemble *A.*

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[1] W. S. W. Kew, U. S. Geol. Surv. Bull. 753, 52, 1924.

[2] W. P. Woodring, Abstract entitled "Age of the Modelo Formation of the Santa Monica Mountains, California," 28th annual meeting, Cordilleran Section, Geological Society of America, Stanford University, California, 1929.

tumidus and these beds are regarded as the approximate equivalent of the Cierbo formation." The determination would indicate that the marine beds are in part equivalent to the Modelo formation exposed at the type section near Modelo Canyon, as now restricted by Hudson and Craig.[1] This location is also north of the Santa Clara Valley but some distance to the west of Mint Canyon.

The association of primitive and advanced types within certain groups of mammals in the Mint Canyon fauna led the writer to search for a break in the sedimentary record of the formation, but none was observed. Beds comprising the formation are heterogenous and vary laterally. There is no well-marked break in type of sediments, although it was observed that beds of reddish tinge predominate in the lower part of the exposed section, intermingled brownish and grayish beds in the middle portion, and grayish colored deposits are particularly in evidence in the uppermost portion. Gray beds are, however, common throughout the formation, and the more highly colored deposits do not show sufficient regularity in their distribution to be useful in establishing zones.

The lower beds are largely coarse red sandstones with interbedded grayish and reddish silts. They are occasionally fossiliferous. In the middle part of the formation brown soily members and gray silty members, both fossiliferous, are interbedded with coarse, gray, cross-bedded conglomerates and fanglomerates. Several of the silty beds in this part of the formation contain many tests of the fresh-water gastropod, *Paludestrina imitator* Pilsbry.[2] These are apparently lacustrine deposits. Occasionally mammalian remains are found in these sediments.

As noted by Kew the Mint Canyon beds are involved in several rather sharp folds west of Bouquet Canyon, but elsewhere are gently folded with structural axes striking northeasterly. A thickness of 4,000 feet plus or minus is assigned by Kew to the entire formation. It appears to the writer that the thickness west of Mint Canyon itself does not greatly exceed 1,000 feet. Here the lower beds are faulted against a schistose basement complex to the north. Beds mapped by Kew as part of the Mint Canyon formation in a large area to the east of Mint Canyon differ lithologically from the deposits west of Mint Canyon, and yielded no fossils.

OCCURRENCE OF THE PALEONTOLOGICAL MATERIAL

The mode of accumulation of the Mint Canyon beds was apparently not favorable to burial of skeletal parts in association. Although effects of transportation were not noticed on specimens, they were probably scattered and exposed to weathering agencies before burial.

[1] F. S. Hudson and E. K. Craig, Bull. Am. Assoc. Pet. Geol., vol. 13, 509-518, 1929.

[2] W. S. W. Kew, *op cit.*, 54, 1924.

Broken teeth and bones are derived from soily accumulations. Lake and stream deposits occasionally contain fossils. Fossiliferous horizons are, however, infrequent. Good specimens are exceedingly rare.

RELATION OF THE MINT CANYON FAUNA TO ITS ENVIRONMENT

The Mint Canyon beds are exposed to the northwest of the San Gabriel Mountains. It appears not unlikely that the range contributed sediments to a broad valley on the northwest during Mint Canyon time. Adjacence to a prominent mountain mass of this type would apparently favor considerable local variety in environment.

Since the region in which the Mint Canyon deposits occur lies geographically contiguous to the Mohave Desert area and was presumably in direct communication with it during the period of accumulation of these sediments, one might expect to find similar environmental conditions prevailing at the Mint Canyon and Barstow localities. As a matter of fact, the similarities in faunal assemblages suggest that this was actually the case.

Seemingly the presence of relatively abundant remains of hypsodont horses, antelopes, camels and rabbits, indicates that the vegetation must have been at least as great as that supported by a semi-arid region. The climate was necessarily more humid than that characterizing the Mohave Desert at the present time.

Great numbers of fresh-water gastropods occurring locally in fine-grained sediments indicate the presence of fresh-water lakes. The occurrence in the Mint Canyon fauna of a turtle, possibly related to *Clemmys,* is supplementary evidence. Rabbits and large tortoises, related perhaps to *Testudo,* may have frequented the more arid districts. The grazing types of mammals with long crowned teeth occupied the grass-covered plains. *Parahippus,* the peccary, and possibly the oreodont, mastodon, and *Miolabis* may have found congenial wooded areas along the streams and beside the lakes.

FAUNAL RELATIONSHIPS

Correlation of the Mint Canyon assemblage with vertebrate faunas of the Pacific Coast Marine Province is rendered difficult by the dearth of comparable forms. It is immediately recognizable that *Merychippus californicus* characterizing the Merychippus zone at Coalinga is inferior in stage of development to the large protohippine types of *Merychippus* and *Hipparion*-like forms from the Mint Canyon. The latter assemblage is definitely later.

Some correspondence is found with the mammalian fauna from the Cuyama region, Ventura County, California, which is described by C. L. Gazin. This occurrence lies to the northwest of Mint

Canyon in the direction of Coalinga. Unfortunately paleontological correlation is possible only on the basis of *Merychippus sumani* which is common to both faunas. Although this similarity does not establish contemporaneity, it suggests agreement to within a comparatively small portion of a period.

Turning to the Great Basin Province we find faunas which are more completely known and which are more closely comparable to that of Mint Canyon. The closest correlative in distance and time, the Barstow, possesses an almost identical equine assemblage, common forms being *Parahippus, Merychippus intermontanus, Merychippus sumani* and *Protohippus.* However, the Mint Canyon fauna shows the introduction of *Hipparion ?* near *mohavense,* related to the Ricardo species, as well as other *Hipparion*-like types. The Ricardo fauna contains also *Pliohippus tantalus* and *Pliohippus fairbanksi* which are absent in both the Barstow and the Mint Canyon, while it lacks *Parahippus ? mourningi* found in the other two faunas. On the basis of the horses present, it would appear that the Mint Canyon is intermediate in age between the Barstow and Ricardo, perhaps bridging in a measure at least the hiatus between the two. The following table illustrates the relationships of these three faunas.

Comparative faunal lists of the Barstow, Mint Canyon and Ricardo

Barstow	Mint Canyon	Ricardo
Aelurodon near wheelerianus	Aelurodon, sp.	Aelurodon aphobus
Lepus	Hypolagus ? cf. apachensis	Lepus or Hypolagus
"Tetrabelodon"	Trilophodon sp.	Trilophodon sp.
Merycochœrus ? buwaldi	Oreodont cf. Merychyus	Merycochœrus (Metoreodon) californicus
Prosthennops ? sp.	Prosthennops ? sp.	
Merycodus necatus ?	Merycodus near necatus	Merycodus near necatus
Merycodus furcatus		Merycodus furcatus
Hypohippus near affinis		
Parahippus ? mourningi	Parahippus ? near mourningi	
Merychippus intermontanus	Merychippus intermontanus	
Merychippus sumani	Merychippus sumani Merychippus sp.	
Protohippus ? or Pliohippus ?	Protohippus sp. Hipparion ? near mohavense	Hipparion mohavense
	Hipparion ? sp.	
		Pliohippus tantalus
		Pliohippus fairbanksi

With the exception of *Alticamelus alexandræ,* the camels of the Barstow are at present too incompletely known to permit comparison with the Mint Canyon forms.

The Mascall fauna appears to be definitely older than the Mint Canyon. The advanced stage shown by *Parahippus ? mourningi* from the Barstow led Merriam to consider it as a primitive *Parahippus* rather than *Archeohippus.* Its advance over *Archeohippus ultimus* Cope from the Mascall is shown by greater size and by the loss of the external cingulum on the cheek-teeth. This difference is noted by Merriam.[1] Teeth of *Merychippus isonesus* from the Mascall are smaller and have a lighter coat of cement than those of *M. sumani.* In the camel group the Mascall and Mint Canyon formations possess comparable forms, *Miolabis transmontanus* and *Miolabis californicus.* The Mint Canyon species is somewhat smaller and more primitive in tooth structure. *Miolabis californicus* is apparently a survivor from an earlier stage in the Miocene.

Hipparion condoni Merriam from the Ellensburg formation of Washington is a primitive type and shows some points of similarity to one of the Mint Canyon forms, *Hipparion ?* sp. A. The appearance in both horizons of primitive Hipparions suggests a closer correspondence between the Mint Canyon and the Ellensburg than between the Mint Canyon and the Mascall.

The Mint Canyon does not admit of close correlation with deposits of the Great Plains Province because of geographic separation. The Santa Fé beds of New Mexico which are referred to the upper Miocene have some comparable forms. It is significant to note the presence of *Merychippus calamarius,* a species closely related to large protohippine horses of the Barstow. Two of these species, *Merychippus intermontanus* and *M. sumani,* are found also in the Mint Canyon. Proboscidea of the *Trilophodon* type occur in both deposits. Frick has established a close time relationship between the Santa Fé and the Barstow. On the basis of this correlation the Mint Canyon might be regarded as somewhat younger than the former horizon.

The Pawnee Creek beds of Colorado possess an earlier assemblage than the Mint Canyon, for like the Mascall the deposits have yielded *Merychippus isonesus.* Matthew [2] has correlated the Pawnee Creek beds with the lower Snake Creek beds of Nebraska because of a close correspondence of faunas. Merychippine forms of these formations are smaller and less advanced than the large protohippine types from the Barstow and Mint Canyon. The upper Snake Creek beds with *Pliohippus* and advanced *Hipparion* are younger than the Mint Canyon.

[1] J. C. Merriam, Univ. Calif. Publ., Bull. Dept. Geol., vol. 11, 477, 1919.

[2] W. D. Matthew, Bull. Am. Mus. Nat. Hist., vol. 50, 72, 1924.

AGE OF THE MINT CANYON

The stratigraphic occurrence of a primitive *Merychippus*, *Parahippus ?* near *mourningi* and *Miolabis californicus* in the lower portion of the exposed Mint Canyon section might be considered as adequate paleontological evidence for assigning an older age to these beds, in which case an unconformity must be assumed. The presence of *Parahippus* in the Barstow detracts from its stratigraphic value in the Mint Canyon by extending the range of the genus into the upper Miocene, where it is found associated with more advanced forms. The occurrence of a primitive *Merychippus* does not indicate necessarily a hiatus between the beds containing this type and the deposits higher in the section. The camel on the other hand, because of its relationship with *Pseudolabis* and *Miolabis,* is suggestive of an older horizon. Aside from these forms with the limitations mentioned the fauna of the Mint Canyon beds has a unified character.

Time relationship of Mint Canyon fauna to Miocene vertebrate and invertebrate faunal horizons of western North America

Period	Pacific Coast Marine Province		Great Basin Province	Great Plains Province
	Marine	Terrestrial		
Upper Miocene	Santa Margarita Cierbo Modelo Briones	Mint Canyon	Ricardo Barstow Cedar Mountain	Santa Fe
Middle Miocene	Temblor (Topanga)	Merychippus zone at Coalinga	Mascall and Virgin Valley	Lower Snake Creek

Faunal relationships suggest that the Mint Canyon formation is younger than the Mascall, Virgin Valley, and Cedar Mountain occurrences, while close to although somewhat younger than the Barstow. The Ricardo is slightly younger than the Mint Canyon. This evidence appears sufficient to assign an upper Miocene age to the formation. Further information bearing upon age is given by the stratigraphic position. If the overlying marine formation is of approximately Cierbo age as believed by Woodring, the Mint Canyon formation is precluded from occupying the uppermost part of the Miocene represented by the Santa Margarita and possibly by a portion of the Cierbo. The Mint Canyon formation is further depressed in the geologic column by the hiatus during which deformation and erosion of the Mint Canyon beds occurred before submergence and deposition of the overlying marine series. Taking into consideration the facts available, it appears that the Mint Canyon beds were deposited during approximately the middle portion of the upper Miocene.

OCCURRENCE OF HIPPARION

A noteworthy feature of the equine group of the Mint Canyon fauna is the diversity of types represented. In this respect similarity to the Barstow fauna is suggested, for in the latter assemblage a wide variety of forms is also found. At both localities are recorded anchitheriine horses related to *Parahippus* or *Archeohippus*. Associated with this form are more progressive types of horses, identified as *Merychippus (Protohippus) intermontanus* and *Merychippus sumani.*

The advanced character of some of the protohippine horses of the Barstow, exhibiting apparently a relationship with the *Hipparion* group, was recognized by Merriam. It is of special interest to note that within the Barstow assemblage there prevailed considerable variation in structural characters at a time not long antecedent to the period of the Ricardo accumulation when a *Hipparion* type with comparatively primitive characters had become definitely established in the California region. In this connection Merriam [1] states: "While it is improbable that the known *Hipparion* forms of the Ricardo fauna are descended directly from any known *Hipparion*-like species of *Merychippus* of the Barstow fauna, the proximity of the two in morphologic characters, geographic situation, and in time, strongly suggest close relationship."

The collections from the Mint Canyon formation have yielded teeth more advanced in structural features than those referable to species of *Merychippus* and tending in some instances toward those characterizing the *Hipparion* group. These forms appear to be somewhat more progressive than the Barstow types, yet have apparently not quite reached the stage of development seen in the typical Hipparions of the Ricardo. An analysis of the characters presented by these forms has inclined the writer to refer them, until known by more complete material, at least tentatively to the genus *Hipparion.*

Should the disposition here made of the forms prove to be correct there may be added reason for assuming that the origin of the *Hipparion* group, as represented by species in the Ricardo, occurred in or near the Mohave area during the later Tertiary.

Moreover, the presence of *Hipparion* or *Hipparion*-like horses in the Mint Canyon, showing resemblances to the Ricardo species, is significant as implying perhaps a greater antiquity to the Ricardo assemblage than has been hitherto assumed.[1]

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[1] J. C. Merriam, Univ. Calif. Publ., Bull. Dept. Geol., vol. 11, 558, 1919.

DESCRIPTION OF FAUNA

TESTUDINATA

Portions of a thick carapace and plastron as well as an associated limb bone indicate the presence in the Mint Canyon vertebrate fauna of a large land tortoise. The carapace has a maximum thickness of 4 cm. This form exceeds *Testudo mohavense* in size.

Fragments of the carapace of a small turtle are frequently encountered in the Mint Canyon formation. The specimens never exceed a thickness of approximately 8 mm. and in this character are to be distinguished from the large form mentioned above. The fragments may represent a fresh-water turtle resembling *Clemmys.*

AVES

A proximal portion of a claw with a bony prominence on the inferior surface is the single record of a bird.

CARNIVORA

Ælurodon sp.

Remains of a single carnivore found in the Mint Canyon represent a canid type related presumably to *Ælurodon.* The material includes several teeth and tooth fragments, No. 125 C. I. T. Coll., belonging to one individual. The upper carnassial, still retained in a fragment of the maxilla, is shown in figure 2, *a* and *b*. A canine and second superior molar are shown in figures 2, *d* and *c*.

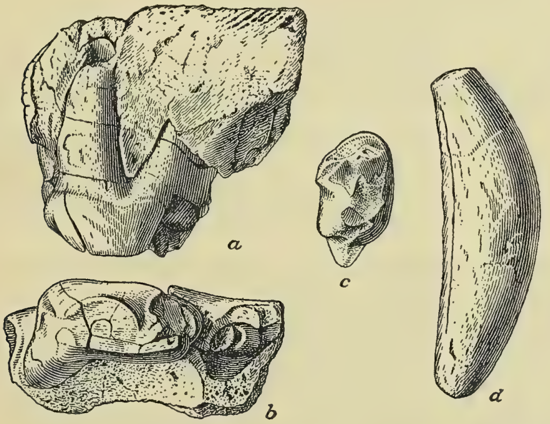

FIG. 2, *a* to *d—Ælurodon* sp., Teeth, No. 125 C.I.T. Coll.; *a,* P$\underline{4}$, lateral view, *b,* P$\underline{4}$, occlusal view, *c,* M$\underline{2}$, occlusal view, *d,* C, lateral view; x 1.0. Mint Canyon Miocene, southern California.

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[1] In recent years the presence of *Hipparion mohavense* in the Ricardo has suffered some loss of value as *prima facie* evidence in support of the view that this fauna is Pliocene in age. Thus Stock and Furlong suggest that the fauna may be, at least in part, transitional from Miocene to Pliocene. Recently Stock has recorded the species, *Hipparion mohavense,* as coming presumably from the Puente formation of southern California. The recognition of *Hipparion* as an autocthonous type in America and the presence of the genus in faunas referred to the Pontian stage in Europe have led Matthew to regard the range of this form as extending backward into the upper

The crown of the canine is relatively slender. P$\underline{4}$ is relatively short and broad compared with *Ælurodon aphobus* Merriam from the Ricardo. A groove situated on the anterior portion of the tooth suggests the presence of a parastyle. This cusp was apparently subdued. The crown gives little indication of the presence of a protocone, but the inner root is very strong. In this respect No. 125 is like *Ælurodon haydeni validus* Matthew and Cook.[1] The protocone ridge of M$\underline{2}$ is almost obliterated by wear. The paracone was apparently the most important cusp.

The Mint Canyon form is much smaller than either *A. aphobus* or *A. haydeni.* The species from the Barstow regarded by Merriam as close to *A. wheelerianus* Cope from the Sante Fé is also larger in size. The protocone and parastyle are more prominently developed than in the Mint Canyon specimen.

Comparative measurements (in millimeters) of teeth

	Ælurodon sp. No. 125, C. I. T. Coll.	Ælurodon aphobus Merriam No. 21507 U. C. Coll.
C, height of crown	*a*10	
P$\underline{4}$, anteroposterior diameter	21.6	32.3
P$\underline{4}$, transverse diameter	10.4	15.
M$\underline{2}$, anteroposterior diameter	9.3	
M$\underline{2}$, transverse diameter	13.5	18.2

a, approximate

LAGOMORPHA

Hypolagus? cf. apachensis Gazin

A number of rabbit teeth have been collected in the Mint Canyon formation. A fragment of a ramus No. 123 C.I.T. is illustrated by figure 3.

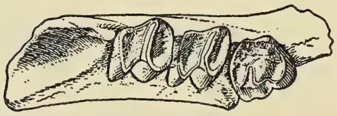

FIG. 3—*Hypolagus ?* cf. *apachensis* Gazin. Fragment of ramus with P$\overline{3}$ to M$\overline{1}$ inclusive, No. 123, C.I.T. Coll.; x 4.0. Mint Canyon Miocene, southern California.

Dice[2] distinguishes members of the lagomorph group on the basis of certain structural features seen in lower premolar three.

In size and cementation, the Mint Canyon specimens represent a stage of development intermediate between *Lepus* and *Archeolagus.* P$\overline{3}$ differs from that of the genotype, *Hypolagus vetus* (Kellogg) from the Virgin Valley beds of Nevada, in greater depth of enamel infolding on the outer side of the tooth. On the inner surface is a groove not found in *H. vetus.* The Mint Canyon form differs widely from the genotype in smaller size.

Miocene. The occurrence of these types in the Mint Canyon underlying marine beds that are presumably upper Miocene in age may be regarded as confirmatory evidence in support of the view that the downward range of the *Hipparion* group is not limited to the Pliocene.

[1] W. D. Matthew, Bull. Am. Mus. Nat. Hist., vol. 50, 100, 1924.

[2] L. R. Dice, Univ. Calif. Publ., Bull. Dept. Geol., vol. 10, 179-183, 1917.

In size $P\overline{3}$ of the Mint Canyon form is close to that of *Hypolagus edensis* Frick from the Eden beds in the vicinity of Mount Eden, southern California, and also to that of *Hypolagus ? apachensis* Gazin[1] from the Cuyama region. The Mint Canyon species differs from *H. edensis* in the shape of $P\overline{3}$ and in the position of the antero-external re-entrant angle. The enamel surface of the inner side is not grooved as in the Mint Canyon specimen or in the type of *H. ? apachensis.* In the latter the loops lie on a line nearly parallel to the longitudinal median, while in *H. edensis* the line to which the loops are tangent is directed inward at a large angle.

The lower molariform teeth have re-entrant angles which extend almost across the crowns. The loop curves posteriorly at its inner extremity. The inner side of each tooth is grooved in contrast to the rounded inner surface of the teeth in *H. edensis.*

The upper molariform teeth have a re-entrant angle with crenulated margins extending a little more than halfway across the crown.

Comparative measurements (in millimeters) of teeth

	Cuyama H. ? apachensis No. 38 C.I.T.	Mint Canyon H.? cf. apachensis No. 113 C.I.T.	H. vetus No.12565 U. C.	H. edensis No. 23376 U. C.
$P\overline{3}$, anteroposterior diameter..	2.3	2.4	2.9	2.4
$P\overline{3}$, transverse diameter..........	2.0	2.2	2.8	2.1
$M\overline{1}$, anteroposterior diameter	2.0	2.0	2.4	2.0
$M\overline{1}$, transverse diameter........	2.1	2.2	3.1	2.2
	No. 39 C.I.T.	No.131 C.I.T.		
$P\underline{4}$, anteroposterior diameter	1.7	1.8		
$P\underline{4}$, transverse diameter..........	2.6	2.7		
$M\underline{1}$, anteroposterior diameter	1.8	1.8		
$M\underline{1}$, transverse diameter........	3.0	3.0		

Proboscidea

Trilophodon sp.

A nearly complete left $M\underline{3}$, No. 120, C.I.T. Coll. (fig. 4 *a* and *b*), belongs to a mastodon presumably related to *Trilophodon.* Fragments of mastodon teeth have been found at several localities. In size the Mint Canyon form is much smaller than *Trilophodon pojoaquensis* Frick from the Santa Fé of New Mexico. No. 120 is considerably smaller than the *Trilophodon* sp. from the Ricardo and is somewhat larger than *Trilophodon productus* Cope from the Santa Fé. Four major crests and a rudimentary fifth crest are present on the tooth crown. The first two crests are worn and the third shows incipient wear.

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[1] C. L. Gazin, this publication, No. VI, 67.

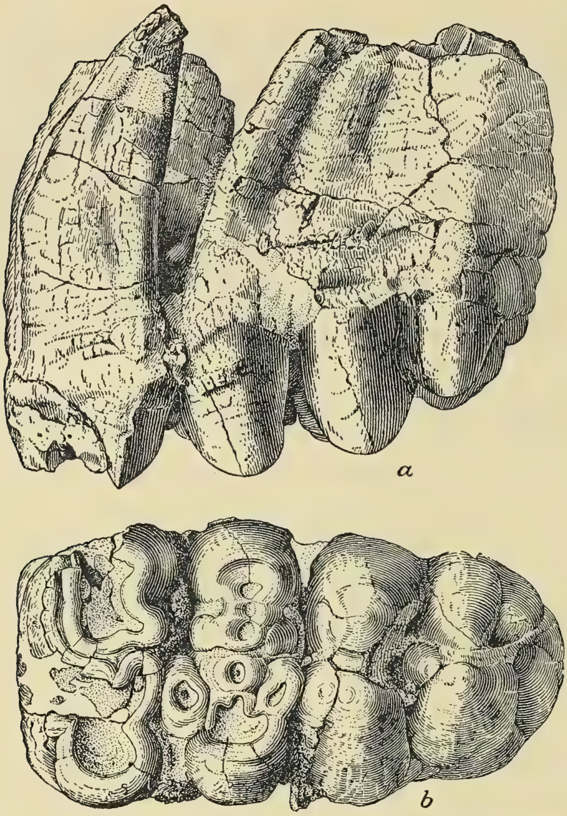

Fig. 4, *a* and *b*—*Trilophodon, sp.* M$\underline{3}$, No. 120 C.I.T. Coll., *a,* lateral view, *b,* occlusal view; x 0.50. Mint Canyon Miocene, southern California.

A cingulum is missing. The first and second crests possess a pattern approximating in degree of complication the species *T. pojoaquensis,* while the third and fourth crests have each a single large tubercle on the outer side and two smaller cusps on the inner side. Fewer accessory tubercles are present on these crests than in *T. pojoaquensis.* Compared with *T. produc-*

Comparative measurements (in millimeters) of M$\underline{3}$

	Trilophodon, sp. No. 120 C. I. T.	Trilophodon, sp. No. 1 L. A. Mus.	T. productus No. 4179 U. S. Nat. Mus.	T. pojoaquensis No. 21115 Am. Mus.
Antero-posterior diameter	156.5	172.7	143	197
Transverse diameter across first crest.	*a* 73.2	*a* 71		
Transverse diameter across third crest.	68.5	69.5		

a, approximate

tus, the pattern seems on the whole more complex. From the Ricardo *Trilophodon* the Mint Canyon specimen differs in greater complexity of the anterior two crests and the smaller number of tubercles present in the posterior portion of the tooth.

EQUIDÆ

Parahippus? (Archeohippus) near mourningi Merriam

Anchitheriine horses in the Mint Canyon assemblage are recorded by a fragment of a jaw belonging to an immature individual. This specimen, No. 23852 from Univ. Calif. Coll. Loc. 3554, possesses Dm$\overline{3}$ and Dm$\overline{4}$ and appeared as shown in figure 5, *a* and *b*. Subsequently the unerupted P$\overline{3}$ and P$\overline{4}$ were removed from the ramus. These teeth are illustrated in figure 5, *c* and *d.*

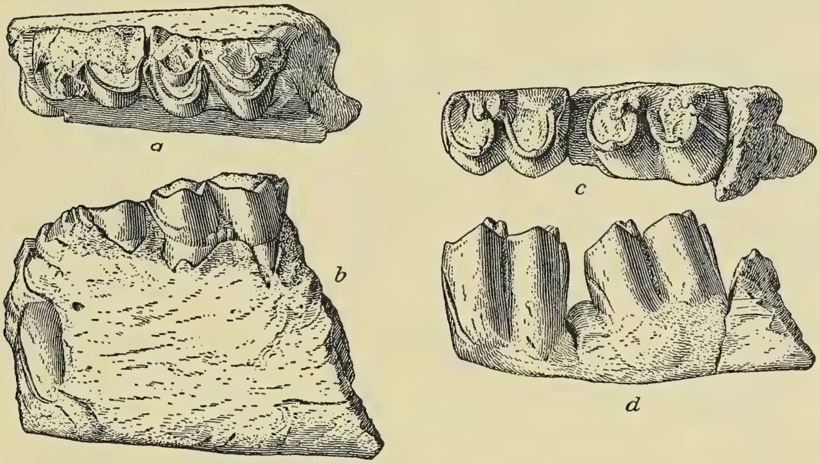

FIG. 5, *a* to *d*—*Parahippus ? (Archeohippus)* near *mourningi* Merriam. Fragment of ramus with deciduous and permanent teeth, No. 23852 U.C. Coll., *a,* occlusal view of Dm$\overline{3}$ and Dm$\overline{4}$, *b,* lateral view of ramus and Dm$\overline{3}$ and Dm$\overline{4}$, *c* and *d,* P$\overline{3}$ and P$\overline{4}$, occlusal and lateral views; x 1.0. Mint Canyon Miocene, southern California.

An internal cingulum is absent on the milk teeth. The prominent cingulum on the anterior side of the crown becomes slight on the outer surface of the protoconid, but terminates in a pronounced cusp in the valley between the protoconid and hypoconid. There is no cingulum on the outer surface of the hypoconid, although a ledge is faintly developed on the posterior side of the crown. The genotype, *Parahippus cognatus* Leidy, is based on deciduous teeth, No. 567 U. S. Nat. Mus. Dm$\overline{2}$ in this form is larger than the deciduous molars of the Mint Canyon species. The metaconid-metastylid column and the entoconid-entostylid column are broader than in No. 23852. The brachydonty of the teeth is comparable.

The permanent teeth having suffered no attrition are rather long crowned. No cement is present and none is reported on the type of the species. The enamel surface is but very faintly rugose and in this respect differs from that in *Parahippus.* A cingulum is present only on the anterior side of the crown. The metaconid and metastylid columns are separated near the top of the crown. The form differs from *Hypohippus* in the absence of an external cingulum and in the separation of the metaconid and metastylid. The entostylid is developed much as in the type of the species.

No. 23852 is larger than any specimen referred to *Archeohippus. Parahippus ? mourningi* from the Barstow which has been assigned to *Archeohippus* by Osborn is somewhat smaller. *Parahippus pawniensis* Gidley from the Pawnee Creek beds is also smaller.

Comparative measurements (in millimeters) of lower teeth

	Parahippus near mourningi No. 23852 U. C.	Parahippus cognatus No. 567 U.S. Nat. Mus.	Parahippus mourningi No. 19764 U. C.	Archeohippus ultimus No. 1700 U. C.	Archeohippus penultimus No. 18950 Am. Mus. Nat. Hist.
Dm$\overline{2}$, antero-posterior diameter ..	.....	22.5[1]			
transverse diameter ..	.....	12.5[1]			
Dm$\overline{3}$, antero-posterior diameter ..	16.7	.....			
transverse diameter ..	*a* 9.8	.....			
Dm$\overline{4}$, antero-posterior diameter ..	17.7	.....			
transverse diameter ..	*a*10	.....			
height of protoconid.	7.8	.....			
P$\overline{3}$, antero-posterior diameter ...	16.8	.....	*a*15.8	12.0	10.1
transverse diameter ...	10.7	.....	10.5	9.8	9.0
height of protoconid..	15.7	.....	.....		
P$\overline{4}$, antero-posterior diameter ...	17.2	.....	15.0	....	10.7
transverse diameter ...	11.2	.....	10.5	....	9.2
height of protoconid..	15.8	.....	.....		

[1] Measurements from figure 71, Osborn's *Revision of the Equidæ,* Mem. Am. Mus. Nat. Hist., N. S., vol. II, Part I, 95, 1918.

a approximate.

Merychippus sumani Merriam

An incomplete upper cheek-tooth, series No. 116 from C. I. T. Coll. Loc. 101 in the Mint Canyon formation, is referable to *Merychippus sumani.* As shown in figure 6, P$\underline{2}$ and the inner portion of P$\underline{4}$ are missing. The teeth are well worn.

As in the type of *M. sumani* from the Barstow the teeth are relatively small, curved and well cemented. The protocone is oval to subcircular in shape and is separate even in well-worn M$\underline{1}$. The fossette borders are relatively complicated.

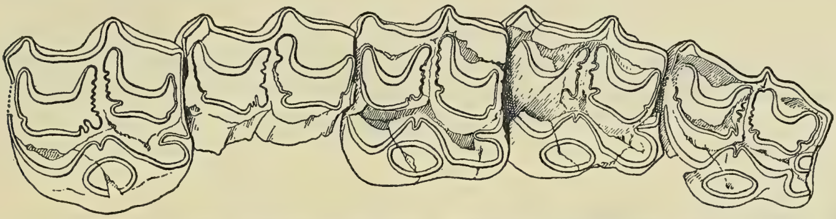

Fig. 6—*Merychippus sumani* Merriam. Superior cheek-tooth series, P$\underline{3}$ to M$\underline{3}$ inclusive, occlusal view, No. 116 C.I.T. Coll.; x 1.0. Mint Canyon Miocene, southern California.

M. sumani is the smallest of the Barstow horses whose similarity to *Merychippus calamarius* (Cope) from the Santa Fé has been noted. In teeth of *M. calamarius* the protocone is not symmetrical as in the Mint Canyon form, but gives rise to an anterior spur. The large form, *Merychippus (Protohippus) intermontanus* Merriam, differs in size, simplicity of fossettes, and early union of protocone and protoconule. On the basis of the material from the Mint Canyon and in the absence of teeth referable *to M. calamarius stylodontus* from this formation the species *M. sumani* and *M. intermontanus* appear clearly as two distinct types.

Comparative measurements (in millimeters) of upper cheek-teeth

	M. sumani No. 116 C.I.T.	M. sumani No. 21422, U. C. type	M. sumani No. 21401 U. C.
P$\underline{3}$, anteroposterior diameter......	21.4	....	20
P$\underline{3}$, transverse diameter................	22.3	....	21.9
P$\underline{3}$, height of crown......................	21.6	....	16
P$\underline{4}$, anteroposterior diameter....	21.0	22.0	20
P$\underline{4}$, transverse diameter..............	....	20.8	21.6
P$\underline{4}$, height of crown......................	24.0		
M$\underline{1}$, anteroposterior diameter....	19.5	19	17.4
M$\underline{1}$, transverse diameter..............	20.8	19.4	20.6
M$\underline{1}$, height of crown.....................	19.9		
M$\underline{2}$, anteroposterior diameter....	20.7	20.8	20
M$\underline{2}$, transverse diameter..............	20.3	18.1	19.3
M$\underline{2}$, height of crown.....................	23.9	32.8	20
M$\underline{3}$, anteroposterior diameter....	21.0	19.7	
M$\underline{3}$, transverse diameter..............	16.8	15.5	
M$\underline{3}$, height of crown.....................	23.0		

Merriam notes that in some characters of the cheek-teeth, *M. sumani* approaches *Hipparion.* According to Merriam, *M. sumani* is clearly distinguished from the latter genus by more strongly curved crowns, greater simplicity of fossettes, and a thinner coating of cement.

Merychippus sp.

M$\underline{3}$, No. 18 from C. I. T. Coll. Loc. 97 and shown in figure 7, *a* to *c*, represents a *Merychippus* form slightly smaller than *Merychippus sumani.*

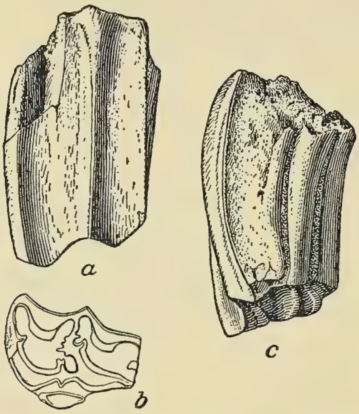

Fig. 7 *a* to *c*—*Merychippus* sp. M$\underline{3}$, No. 18 C.I.T. Coll., *a,* outer view, *b,* occlusal view, *c,* posterior view; x 1.0. Mint Canyon Miocene, southern California.

In character of size, this specimen approaches *M. californicus* of the Merychippus zone of the North Coalinga region, California. The curvature of the crown, as seen in side view (fig. 7*c*), is comparable to that noted in last upper molar teeth belonging to a small species of *Merychippus* from the Barstow. The latter may represent *M. sumani.* In No. 18 C. I. T. the outer surface of the crown is devoid of cement, and the mesostyle, while somewhat worn, appears to be slender. The transverse diameter of the tooth diminishes very pronouncedly toward the grinding surface, perhaps no more so than in *Merychippus* teeth from the Barstow.

While the tooth is but slightly worn, the protocone is seen to occupy an almost median position on the inner side. This cusp is a flattened oval in cross-section and, judging from its form and position, is separated from the protoconule up to an advanced stage of wear. Plication of the fossettes resembles that in *M. californicus* and in small teeth of *Merychippus* from the Barstow. An unusual feature is presented in the postfossette, which remains open posteriorly. This opening prevails to the base of the crown. A similar character is exhibited by teeth of a more primitive type of *Merychippus* described by J. P. Buwalda [1] from the Phillips Ranch Miocene of the Tehachapi region, California.

Teeth of *M. californicus* exhibit considerable variation in size and enamel pattern. The Mint Canyon specimen is comparable to the smaller teeth representing *M. californicus.* The protocone in No. 18 is flatter and the anterior spur extending toward the protoconule, which is usually present in *M. californicus,* is absent in the former. A single tooth of *M. californicus,* No. 21280 U. C., figured by Merriam, [2] has a somewhat similar pattern. It is significant to note that while many teeth of *M. californicus* are available from the North Coalinga locality, not a single specimen has been observed in which the postfossette is open posteriorly after moderate wear.

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[1] J. P. Buwalda, Univ. Calif. Publ., Bull. Dept. Geol., vol. 10, 78, 1916.

[2] J. C. Merriam, Trans. Am. Phil. Soc., N.S. vol. 22, Part II, 8, 1915.

Teeth of *M. sumani* from the Barstow, in comparison with No. 18 C. I. T. possess a protocone tending to become circular, a heavier coat of cement and are of larger size. However, in the collections available from this horizon teeth are present which approximate rather closely in size, cementation, and enamel pattern, No. 18 from the Mint Canyon. In view of the primitive character presented perhaps by the open postfossette in No. 18, it should be indicated that this tooth was found in the lower portion of the Mint Canyon formation.

Comparative measurements (in millimeters) of $M\underline{3}$

	Merychippus sp. No. 18 C.I.T.	M. californicus No. 21246 U.C.	M. sumani No. 21422 U.C.
Anteroposterior diameter	18.1	17.7	19.7
Transverse diameter....	15.0	15.2	15.5
Height of crown........	31.0	29.5	32.8

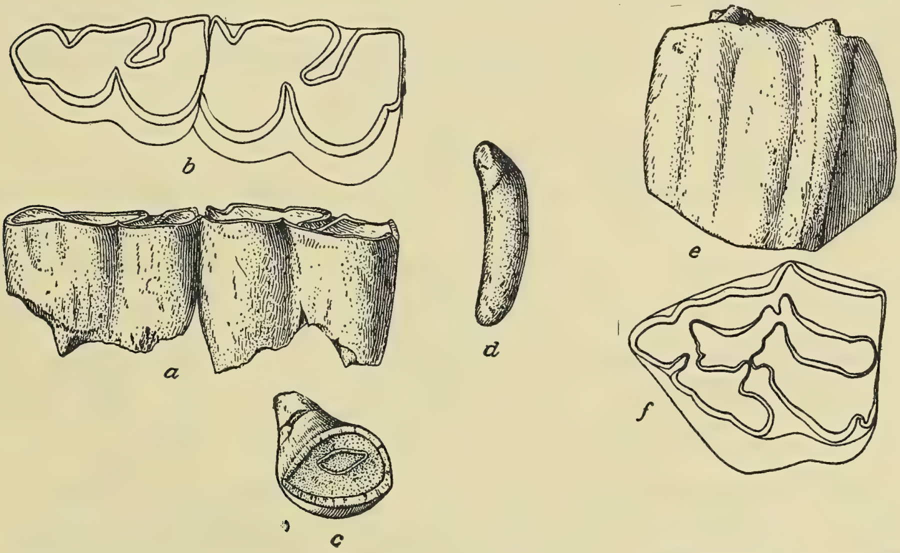

Fig. 8, *a* to *f*—*Merychippus (Protohippus) intermontanus* Merriam. *a* and *b*, $P\overline{2}$ and $P\overline{3}$, No. 30041 U.C. Coll., lateral and occlusal views, *c*, incisor, No. 30043 U.C. Coll., occlusal view, *d*, canine, No. 30044 U.C. Coll., lateral view, *e* and *f*, $P\underline{2}$, No. 30042 U.C. Coll., lateral and occlusal views; x 1.0. Mint Canyon Miocene, southern California.

Merychippus (Protohippus) intermontanus Merriam

A much worn $P\underline{2}$, No. 30042 U. C. (fig. 8, *e* and *f*), and well-worn lower premolars two and three, No. 30041 U. C. (fig. 8, *a* and *b*), are assigned to this species. An incisor, No. 30043 U. C. (fig. 8*c*), and a canine, No. 30044 U. C. (fig. 8*d*), apparently belong to the same form. All specimens were found at Univ. Calif. Coll. Loc. 3555.

The fossettes in $P\underline{2}$ are joined and communicate with the inner side of the tooth by a valley situated between the protocone and hypocone. The fossette borders are simple as in the type of the species. The enamel pattern noted in No. 30042 occurs in both merychippine and protohippine forms. *Merychippus sejunctus* (Cope) from the Pawnee Creek beds of northeastern Colorado and *Protohippus perditus* (Leidy) from the Niobrara River formation of Nebraska present a similar stage of development of tooth pattern. No. 30042 is much larger than the type of *M. sejunctus* and somewhat larger than that of *P. perditus*. *Merychippus (Protohippus) intermontanus* from the Barstow is similar in enamel pattern although somewhat smaller in size.

Comparative measurements of teeth (in millimeters)

	M. intermontanus No. 30042 U. C. Mint Canyon	M. intermontanus type No. 21400 U. C. Barstow	M. c. stylodontus No. 21404 U. C. Barstow
$P\underline{2}$, anteroposterior diameter	32.1	27.8	28.9
$P\underline{2}$, transverse diameter	24.2	18.5	24.2
$P\underline{2}$, height of crown	29.0		
	No. 30044 U. C.	No. 21459 U. C.	
C, anteroposterior diameter	4.8	3.9	
C, transverse diameter	4.1	4.3	
	No. 30043 U. C.	No. 21459 U. C.	No. 21463 U. C.
$I\underline{2}$, anteroposterior diameter	10.5	7.7	7.2
$I\underline{2}$, transverse diameter	13.9	11.6	13.2
$I\underline{3}$, anteroposterior diameter	8.8	*a* 5.7	
$I\underline{3}$, transverse diameter	13.9	5.9	12.8
	No. 30041 U. C.	No. 21228 U. C.	No. 21392 U. C.
$P\overline{2}$, anteroposterior diameter	21.3	21.2	21.8
$P\overline{2}$, transverse diameter	15.0	....	10.6
$P\overline{3}$, anteroposterior diameter	21.0	20.4	20.4
$P\overline{3}$, transverse diameter	17.0	14.2	12.0

a, approximate

The two lower premolars have a simple pattern (fig. 8, *a* and *b*), comparable to that found in *M. sejunctus* and *M. intermontanus* after considerable wear. These teeth are much larger than the corresponding teeth of *M. sejunctus* and are heavily cemented. The metaconid-metastylid column is relatively short anteroposteriorly. The groove flattens out near the base of the crown. The entostylid is obliquely truncated anteriorly. These teeth resemble those of *Protohippus.*

As previously mentioned, the merychippine forms of the Barstow are closely interrelated. To quote from Merriam:[1] "The large *M. intermontanus* closely approaches the *M. calamarius stylodontus* form through the medium of specimens like No. 21409, in which the protocone unites with the protoconule in incipient wear and the fossettes have relatively simple borders. The crowns are, however, much larger in *M. intermontanus.*" While a slight discrepancy in size remains, the similarity of crown pattern between the teeth from the Mint Canyon and those of the type from the Barstow seemingly warrants the recognition of the former as belonging to the *M. intermontanus* group.

The generic determination of these forms as *Merychippus* is doubtful. In this connection it is interesting to note that Merriam states: "In the series of *Merychippus* forms of the Barstow fauna as now known [1919], the range of characters very nearly includes the range from *Merychippus* to *Protohippus* and *Hipparion.* In the large *M. intermontanus* there is no clear separation from *Protohippus* on characters that have been used up to the present time." In size the Mint Canyon species exceeds that of some forms of *Protohippus.* Evidently the stage of evolution represented by *M. intermontanus* is transitional between *Merychippus* and *Protohippus.*

Protohippus sp.

M3̲, No. 126 from C. I. T. Coll. Loc. 100 (fig. 9*a*), is referable to this genus. The tooth is in an advanced stage of wear. It is heavily cemented.

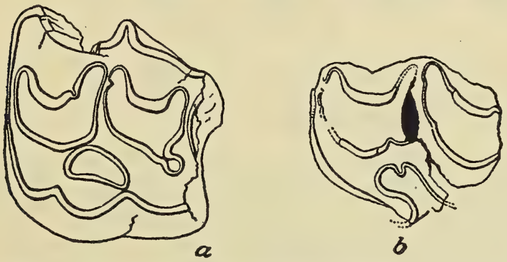

Fig. 9, *a* and *b*—*Protohippus* sp. *a*, M3̲, No. 126 C.I.T. Coll., occlusal view, *b*, upper cheek-tooth, No. 30045 U.C. Coll.; x 1.0. Mint Canyon Miocene, southern California.

The enamel borders of the fossettes are very simple. An isolated enamel loop lying to the inner side of the fossettes in this specimen is seen also in well-worn teeth of *Protohippus placidus*, *Protohippus niobrarensis*, *P. profectus* and *P. perditus secundus* as well as in some forms of *Pliohippus.* The crown of No. 126 is quite large and compares favorably in size with teeth of the larger members of the *Protohippus* group. No. 126 greatly exceeds teeth of *Merychippus* in size.

A portion of another upper cheek tooth, No. 30045 U. C., is also apparently referable to this genus. No. 30054 differs from teeth referred to *Merychippus* in the excessive simplicity of its regular crescentic fossettes. The protocone is united to the protoconule and the hypocone is apparently attached to the metaconule. A pli caballin is present. Figure 9*b* illustrates this tooth.

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[1] J. C. Merriam, Univ. Calif. Publ., Bull. Dept. Geol., vol. 11, 484, 1919.

Comparative measurements (in millimeters) of M$\underline{3}$

	Protohippus, sp. No. 126 C.I.T.	M. intermontanus No. 21400 U. C.	P. profectus No. 8349 Am. Mus.	Pliohippus spectans No. 22388 U.C.
Anteroposterior diameter	28.4	24.9	24	27.2
Transverse diameter	27.7	21.0	20	22
Height of crown..	19.7	....	36	

Hipparion ? sp. A.

Specimens representing this form are three lower cheek-teeth, No. 30047 from Univ. Calif. Coll. Loc. 3555 (fig. 10, *a* and *b*). The teeth show the effects of weathering and are in an advanced stage of wear. To this form is also assigned M$\underline{3}$, No. 30048 from Univ. Calif. Coll. Loc. 3564. All of the specimens are relatively large teeth and are heavily cemented. The metaconid-metastylid column is long anteroposteriorly as in *Hipparion.* The groove is especially well developed in P$\overline{3}$, but in all of the teeth it continues to the base of the crown. This feature is not marked in *Merychippus* or *Protohippus.* The groove, however, is not so broad or deep as in most Hipparions. The teeth possess an antero-external enamel fold on the protoconid not found in *Pliohippus.* In size of cross-section they exceed the most advanced merychippine types.

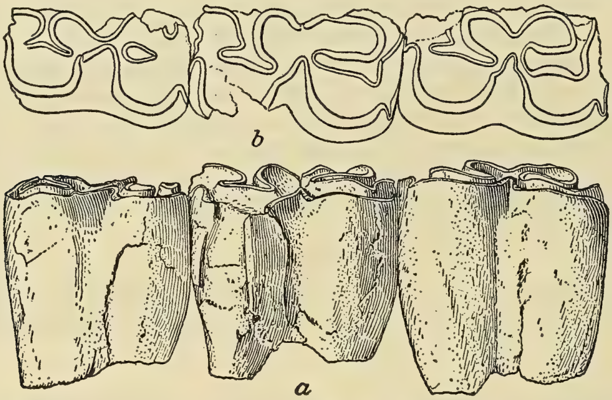

Fig. 10, *a* and *b*—*Hipparion ?* sp. A. P$\overline{3}$, P$\overline{4}$, M$\overline{1}$, No. 30047 U.C. Coll., lateral and occlusal views; x 1.0. Mint Canyon Miocene, southern California.

The metaconid is considerably larger than the metastylid. The anteroposterior diameter of the column which they form is greater than that of *Hipparion condoni* Merriam from the Ellensburg formation of south-central Washington and is comparable to that in other species of *Hipparion.* Valleys adjacent to the metaconid-metastylid are compressed and serve to emphasize the large proportions of the column. The prominent antero-external ridge on the protoconid is likewise present in *H. condoni.* This ridge is small when found in *H. mohavense.*

Some differences are to be noted between the Mint Canyon form and several members of the genus *Hipparion.* Flattening of the exterior margin of the protoconid and hypoconid is not so marked as in species of *Hipparion.* The entoconid is large and projects anteriorly but there is no hypoconulid spur to be noticed on the inner margin. In general the valleys are compressed to a degree comparable to those in *Hipparion.*

From *H. mohavense* the Mint Canyon form differs in the shape of the entoconid, in the presence of a marked antero-external fold and in the preponderance in size of metaconid over metastylid.

These teeth represent a form of the size of *Hipparion* sp. B. from the Mint Canyon. The antero-external ridge is present on both. However, the metaconid-metastylid groove is not so broad or deep in species A. In *Hipparion ?* sp. B. the depth of the groove increases with wear. Likewise this form has a marked hypoconulid separated by a groove from the entoconid. In *Hipparion ?* sp. A. the isthmus is broad and is penetrated by an enamel tongue from the protoconid and hypoconid. In species B. the isthmus is narrow and the tongue does not seem to be appreciably deeper at the base of the crown than at the wearing surface. The differences in pattern do not seem to be entirely attributable to wear. The type of *Hipparion* represented by *Hipparion ?* sp. A. is somewhat closer to the protohippine stem than is either *Hipparion ?* sp. B. or *Hipparion mohavense.*

Comparative measurements (in millimeters) of lower cheek-teeth

	Hipparion?sp.A. No. 30047 U. C.	H. condoni No. 672 Univ. Oregon	H. mohavense No. 19787 U. C.
$P\overline{3}$, anteroposterior diameter	23.9	....	23.5
$P\overline{3}$, transverse diameter	15.3	....	11.7
$P\overline{3}$, height of crown	24.5		
$P\overline{4}$, anteroposterior diameter	26.0	21.0	23.8
$P\overline{4}$, transverse diameter	11.6	11.1	11.9
$P\overline{4}$, height of crown	24.5	31.0	32.0
$M\overline{1}$, anteroposterior diameter	22.4	17.6	
$M\overline{1}$, transverse diameter	11.6	10.3	
$M\overline{1}$, anteroposterior diameter of metaconid-metastylid column	14.2	11.2	

Hipparion ? sp. B.

The form represented by Nos. 114 and 115 C.I.T. Coll. Vert. Pale. is one of the largest of the Mint Canyon horses. A well-worn upper tooth (fig. 11, *c* and *d*), which may be $M\underline{1}$, possesses a straight crown. The mesostyle is unusually heavy. The fossettes are relatively simple for *Hipparion,* especially the postfossette. The protocone is oval and larger than the hypocone. The former is still separate from the protoconule but the enamel borders are tangent. The hypocone is strongly united to the metaconule. A pli caballin is present.

Simple fossette borders are usually diagnostic of *Protohippus,* while those of *Hipparion* are usually relatively complex. Crowns of *Hipparion* teeth are always nearly straight, whereas those of *Protohippus* are but occasionally straight. When considered in connection with the straightness of crown, the isolation of the protocone seems to indicate closer affinity with *Hipparion* than with *Protohippus.*

The two lower cheek teeth (fig. 11, *a* and *b*), considered as belonging to this type, were not found intimately associated with the upper molar. The specimens were found on opposite drainage slopes of the same exposure, although they may possibly have been derived from the same bed. The teeth are fairly complete, although they were collected in fragmentary condition. The enamel has largely flaked off.

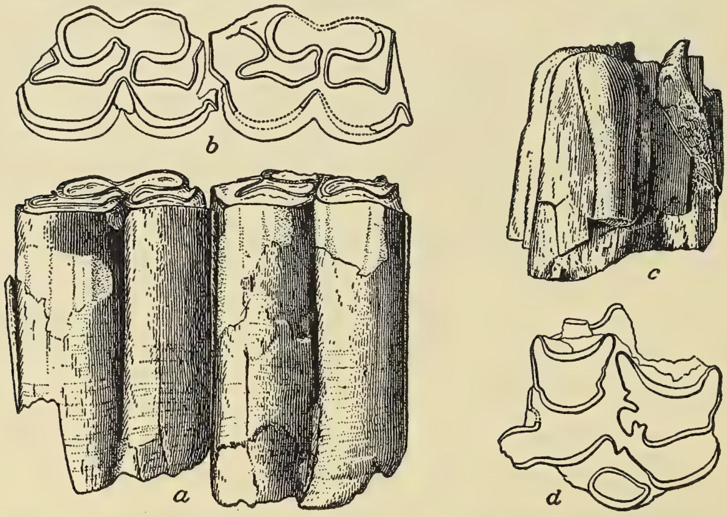

Fig. 11, *a* **to** *d*—***Hipparion ?*** **sp. B.** *a* **and** *b,* **lower cheek-teeth, No. 115 C.I.T. Coll., lateral and occlusal views,** *c* **and** *d,* **upper cheek-teeth, No. 114 C.I.T. Coll., lateral and occlusal views; x 1.0. Mint Canyon Miocene, southern California.**

In these teeth as in those of *Hipparion ?* sp. A., the outer margins of the protoconid and hypoconid tend to be more rounded than in most species of *Hipparion.* An antero-external ridge is present on the protoconid. The metaconid and metastylid columns are defintely separated to the base of the crown. The isthmus is narrow and the tongue of enamel from the protoconid and hypoconid does not penetrate it. The entoconid is somewhat rectilinear and a hypoconulid is present. The crowns are long and the pattern seems to warrant assigning the form tentatively to *Hipparion* rather than to any other genus.

The Mint Canyon type differs from *Merychippus sumani* and *Hipparion gratum* in much larger size. From *Hipparion mohavense* it differs in simpler fossette borders and rounder protocone. *H. platystyle* has a flatter protocone and the fossettes are narrower transversely. *Hipparion ?* sp. B. may represent a type intermediate between *Protohippus* and *Hipparion* with perhaps a relationship tending more toward the latter genus than toward the former.

Comparative measurements (in millimeters) of teeth

	Hipparion ? sp. B. No. 114 C. I. T.	Hipparion ? sp. A. No. 30047 U. C.	Hipparion mohavense callodonte No. 21311 U. C.	Merychippus intermontanus No.21399U.C.
$M\underline{1}$, anteroposterior diameter	26.2	....	24.5	22.0
$M\underline{1}$, transverse diameter	27.3	....	22.6	26.0
$M\underline{1}$, height of crown	27.0			
	No.115 C.I.T.			No. 21459 U. C.
$P\overline{3}$, anteroposterior diameter	24.9	23.9	27.0	25.1
$P\overline{3}$, transverse diameter	14.6	15.3	13.7	12.2
$P\overline{3}$, height of crown	41.3	24.5		
$P\overline{4}$, anteroposterior diameter	25.7	26.0	27.4	24.7
$P\overline{4}$, transverse diameter	14.6	11.6	13.0	12.0
$P\overline{4}$, height of crown	35.2	24.5	51.0	
$P\overline{4}$, anteroposterior diameter metaconid-metastylid column	16.3	14.2		

Hipparion ? near mohavense Merriam

Two upper teeth, $Dm\underline{4}$ and $M\underline{1}$ (fig. 12*a*), No. 15 Los Angeles Museum Coll., from the Mint Canyon deposits presumably represent a species closely related to *Hipparion mohavense.* Occurring at the same locality (L. A. Mus. Coll. Loc. 1006) was a portion of a lower jaw containing $P\overline{2}$, $P\overline{3}$, and a portion of $P\overline{4}$ (fig. 12, *b* and *c*), apparently referable to the same species. Specimen No. 124 from C. I. T. Coll. Loc. 100, including $Dm\underline{3}$ and $Dm\underline{4}$ (fig. 13*d*), and two upper molars (fig. 13*a* to *c*), and (fig. 13*e* to *h*), also belongs to this form. The upper teeth are slightly curved and are heavily cemented. The protocone is enlarged and separate, while the hypocone is reduced. Fossette borders are complicated. In the lower teeth the metaconid-metastylid column is separate to the base of the crown as is typical in *Hipparion.*

Among the infoldings of the enamel present on the crown are the pli crochet, pli caballin, pli prefossette, pli postfossette, and the pli hypostyle. One-fourth of the length of the crown from the bottom, the protocone is united to the protoconule. The juncture is effected at the anterior end of the protocone and the pli caballin has disappeared.

A number of enamel folds are present in the lower teeth. There is a tendency to form a small antero-external fold on the protoconid. As in *Hipparion mohavense callodonte* a fold is present on the anterior margin of the hypoconid with a corresponding fold projecting into the valley opposite it. The outer margins of the protoconid and hypoconid are more rounded than is usually the case in *Hipparion.*

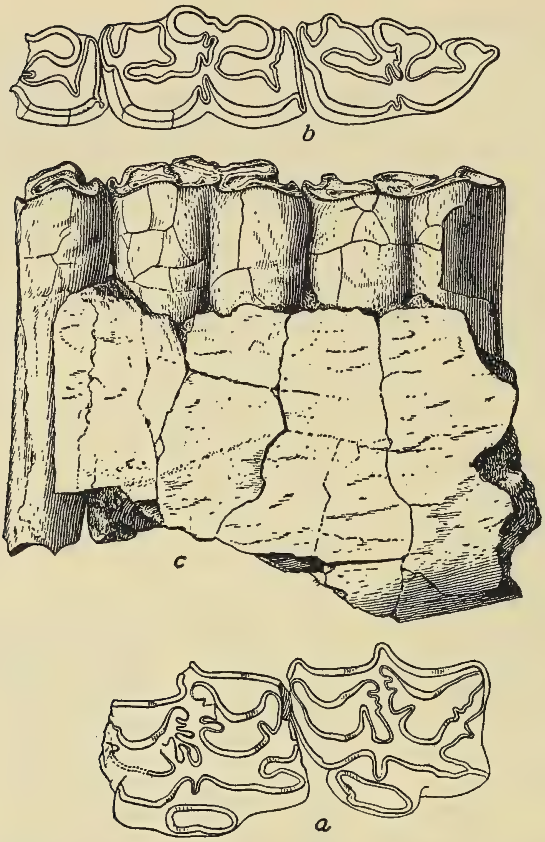

Fig. 12, *a* to *c*—*Hipparion ?* near *mohavense* Merriam. *a,* $\mathrm{Dm}\underline{4}$ and $\mathrm{M}\underline{1}$, No. 15 L.A. Mus. Coll., occlusal view, *b* and *c,* jaw fragment with $\mathrm{P}\overline{2}$, $\mathrm{P}\overline{3}$, and portion of $\mathrm{P}\overline{4}$, No. 15, L.A. Mus. Coll., lateral and occlusal views; x 1.0. Mint Canyon Miocene, southern California.

Like the variety *Hipparion mohavense callodonte,* the Mint Canyon form exceeds *Hipparion mohavense* in size and in the anteroposterior length of the protocone. The crown surface of *H. mohavense callodonte* in contrast to that of the Mint Canyon species shows a large number of enamel plications which are distinctly angular. The differences in crown pattern may be due in part at least to wear. Teeth of the type specimen from the Ricardo are but slightly worn, whereas those of the Mint Canyon species are moderately worn. It has been recognized that the number and complexity of enamel folds may vary considerably within the range of the length of the crown. A section through the type specimen, No. 21311 U.C., made at a point approximately 4 mm. below the grinding surface exhibits a pattern more closely resembling that in teeth from the Mint Canyon.

The slightly greater curvature of crown of the upper cheek-teeth, greater simplicity of fossette borders, and an earlier union of protocone and protoconule in the Mint Canyon form, in contrast to the structural characters of the teeth in the Ricardo Hipparions, might be expected if the Mint

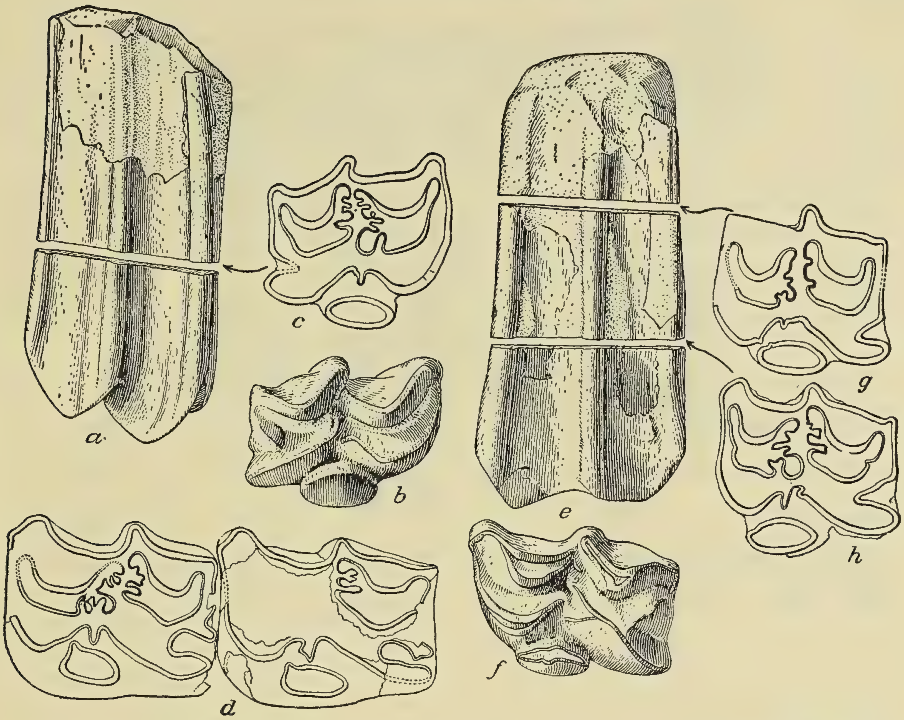

FIG. 13, *a* to *h*—*Hipparion ?* near *mohavense* Merriam. Permanent and deciduous upper cheek-teeth, No. 124 C.I.T. Coll. *a, b,* and *c,* $\mathrm{M}\underline{1}$?, lateral and occlusal views and section through crown, *d,* $\mathrm{Dm}\underline{3}$ and $\mathrm{Dm}\underline{4}$, occlusal views, *e* to *h,* $\mathrm{M}\underline{2}$, lateral and occlusal views and two sections through crown; x 1.0. Mint Canyon Miocene, southern California.

Canyon species were considered as a stage antedating the appearance of true *Hipparion.* Possibly the distinctions here noted are sufficiently diagnostic to warrant the recognition of a new specific type. If the Mint Canyon form falls within the limits of the genus *Hipparion,* the characters possessed by this type suggest one of the more primitive representatives of the group.

Merriam[1] has noted that *H. mohavense* seems more closely related to *H. richthofeni* of China than to previously described American forms. Concerning *H. mohavense callodonte* he remarks: "In many respects *Hipparion mohavense callodonte* of the Ricardo *Hipparion* group resembles a type from the Island of Samos, which has been referred to *H. gracile.* In this Samos form the protocone is much more compressed than in typical *H. gracile* and exceeds the degree of flattening in *H. m. callodonte.* The enamel folds are complicated much as in *H. gracile, H. richthofeni,* and *H. mohavense.*"

Rhinocerotidæ

Rhinocerotid indet.

A fragment of a jaw of an immature animal, No. 20 L. A. Mus. Coll., belongs to a rhinocerotid type. Tooth fragments, No. 127 C. I. T., of an adult individual show a crown length of approximately 41 mm.

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[1] J. C. Merriam, Univ. Calif. Publ., Bull. Dept. Geol., vol. 11, No. 5, 557, 1919.

Comparative measurements (in millimeters) of teeth

	H. near mohavense No. 15 L. A. Mus.	H. near mohavense No. 124 C. I. T.	H. m. callodonte No. 21311 U. C. type	H. mohavense No. 19787 U. C.
Dm$\underline{3}$, anteroposterior diameter	....	26.9		
Dm$\underline{3}$, transverse diameter	....	23.1		
Dm$\underline{4}$, anteroposterior diameter	27.3	28.3		
Dm$\underline{4}$, transverse diameter	22.0	*a*22.6		
M$\underline{1}$, anteroposterior diameter	27.8	26.0	24.5	21.4
M$\underline{1}$, transverse diameter	22.8	22.8	22.6	22.0
M$\underline{2}$, anteroposterior diameter	....	23.6	24	21.6
M$\underline{2}$, transverse diameter	....	21.8	20.4	20.0
M$\underline{2}$, height of crown	....	42.3+	41.0	35.5
				No. 21348
P$\overline{2}$, anteroposterior diameter	25.0	....	28.4	23.8
P$\overline{2}$, transverse diameter	12.9	....	12.0	11.4
P$\overline{3}$, anteroposterior diameter	25.3	....	27.0	
P$\overline{3}$, transverse diameter	14.5	....	13.7	
P$\overline{4}$, anteroposterior diameter	....	....	27.4	
P$\overline{4}$, transverse diameter	*a*14.0	....	13.0	
P$\overline{4}$, height of crown	46.6	....	51.0	44.0

a, approximate.

Tagassuidæ

Prosthennops ? sp.

A fragment of a mandibular ramus, No. 112 C. I. T. (fig. 14, *a* to *c*), was obtained at C. I. T. Coll. Loc. 98. This specimen includes a portion of Dm$\overline{4}$ with P$\overline{4}$ exposed below this tooth, M$\overline{1}$ and M$\overline{2}$, and indicates the presence of a dicotyline form. P$\overline{4}$ was removed from the jaw and is shown in figure 14*c*. Fragments of a canine were associated with this material.

The canine has an inequilateral triangular aspect in cross-section, the outer slightly convex face being the broadest, the inner nearly flat face being next, and the posterior slightly concave surface being smallest in breadth.

Dm$\overline{4}$ is very much worn and is being replaced by P$\overline{4}$. The last premolar has two cusps on the anterior crest and a lower posterior crest. M$\overline{1}$ exhibits a moderate state of wear, the cusps having been reduced. M$\overline{2}$ is larger

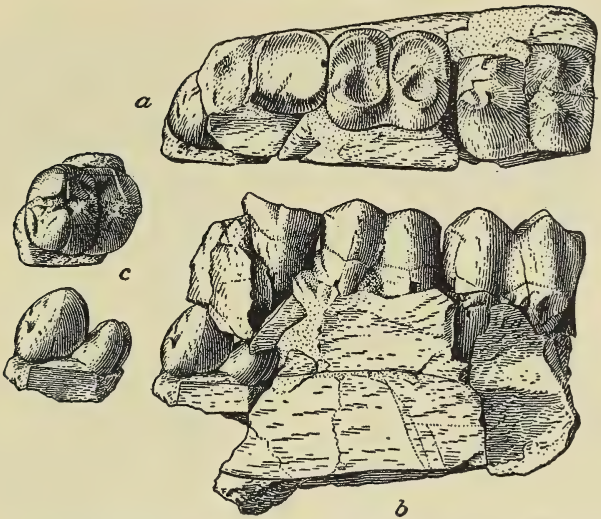

FIG. 14, *a* to *c*—*Prosthennops ?* sp. Fragment of ramus with permanent and deciduous teeth, No. 112 C.I.T. Coll., *a* and *b*, occlusal and lateral views of jaw and Dm$\overline{4}$, M$\overline{1}$, and M$\overline{2}$, *c*, P$\overline{4}$, occlusal and lateral views; x 1.0. Mint Canyon Miocene, southern California.

Comparative measurements (in millimeters)

	Prosthennops ? sp. No. 112 C. I. T. Mint Canyon	Prosthennops ? sp. No. 23863 U. C. Rattlesnake
Dm$\overline{4}$, anteroposterior diameter	....	17.9
Dm$\overline{4}$, transverse diameter	10.5	9.3
P$\overline{4}$, anteroposterior diameter	15.0	
P$\overline{4}$, transverse diameter	11.0	
M$\overline{1}$, anteroposterior diameter	16.0	16.6
M$\overline{1}$, transverse diameter	12.6	11
M$\overline{2}$, anteroposterior diameter	17.0	18.3
M$\overline{2}$, transverse diameter	13.8	12.8
Depth of lower jaw between M$\overline{1}$ and M$\overline{2}$	*a*30	34
Thickness of lower jaw below M$\overline{1}$	22	17.4
	No. 112 C.I.T.	No. 23866 U. C.
C$\overline{1}$, anteroposterior diameter	12.5	13.0
C$\overline{1}$, transverse diameter	8.3	8.0

a, approximate

than $M\overline{1}$ and the cusps on the anterior and posterior portions of the tooth are separated by a transverse indentation.

Dearth of peccary material from either older or contemporaneous vertebrate horizons in western North America makes a comparison of the present specimen difficult. Comparison with *Prosthennops ?* sp. from the Rattlesnake serves to emphasize the more quadrate aspect of the teeth in No. 112, indicating, perhaps, that the Mint Canyon form is not so far advanced as that of the Rattlesnake.

Camelidæ

Miolabis californicus n. sp.

Type specimen, No. 30046, University of California collection, from U. C. Coll. Loc. 3568, Mint Canyon Miocene. The type of this species is the greater portion of the facial and palatal region of an adult skull (fig. 15, *a* and *b*). Also associated with the type are several fragmentary skeletal elements.

Specific characters—Dental formula, $I\underline{3}$, $C\underline{1}$, $P\underline{4}$, $M\underline{3}$. Incisors relatively heavy. Slight reduction of premolars. $P\underline{2}$ two-rooted. Molars subquadrate. Premaxilla not reduced. Muzzle short and elevated. Infraorbital foramen above posterior portion of $P\underline{4}$ and anterior portion of $M\underline{1}$. Shallow malar fossæ. Small size.

Miolabis californicus is among the smaller cameloid forms. It is smaller than *Miolabis transmontanus* (Cope) and is apparently comparable in size to *Paratylopus cameloides* (Wortman). The muzzle is short and relatively high, suggesting *Paratylopus sternbergi* (Cope). The apparent depression of the muzzle on the basifacial axis seen in figure 15*b* may be due to imperfect contact on a fracture. As in the genotype, *Miolabis transmontanus,* the muzzle is moderately compressed laterally.

The infraorbital foramen is situated above the anterior part of $M\underline{1}$ and the posterior part of $P\underline{4}$. A groove, the length of $P\underline{4}$, projects anteriorly. In *Poëbrotherium wilsoni* Leidy, *Paratylopus sternbergi* (Cope), and *Protolabis montanus* Douglas this groove is situated farther forward.

The malar fossæ are broad and shallow in *M. californicus.* Illustrations of *Poëbrotherium wilsoni* and *Paratylopus sternbergi* given by Wortman do not show prominent fossæ. In this respect *M. californicus* appears similar to *P. sternbergi.* In the specimens of *P. cameloides* from the John Day described by Lull[1] there is a deep depression on either side of the maxillary.

The diastemata of *Poëbrotherium* are short and the genus is more primitive in this respect than *Miolabis. Paratylopus sternbergi* is comparable to No. 30046 in shape of skull and in the absence in deep malar fossæ. The John Day type is smaller than the Mint Canyon form. In *Protomeryx* as in *Paratylopus* the orbit is closed posteriorly. Unfortunately, this region is missing in the type of *M. californicus.*

Wortman notes that the $P\underline{2}$ in *Miolabis transmontanus* is markedly reduced from that in *Paratylopus cameloides.* In *M. californicus* the premolar dentition is if anything heavier than in *P. cameloides.* $M\underline{1}$ is subquadrate, while $M\underline{2}$ and $M\underline{3}$ are more elongate. The cheek-teeth are subhypsodont, being slightly higher crowned than those of *P. cameloides* and probably similar in this character to those of *M. transmontanus.* In *M.*

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[1] R. S. Lull, Am. Jour. Sci., (5), vol. 1, pages 392 - 404, 1921.

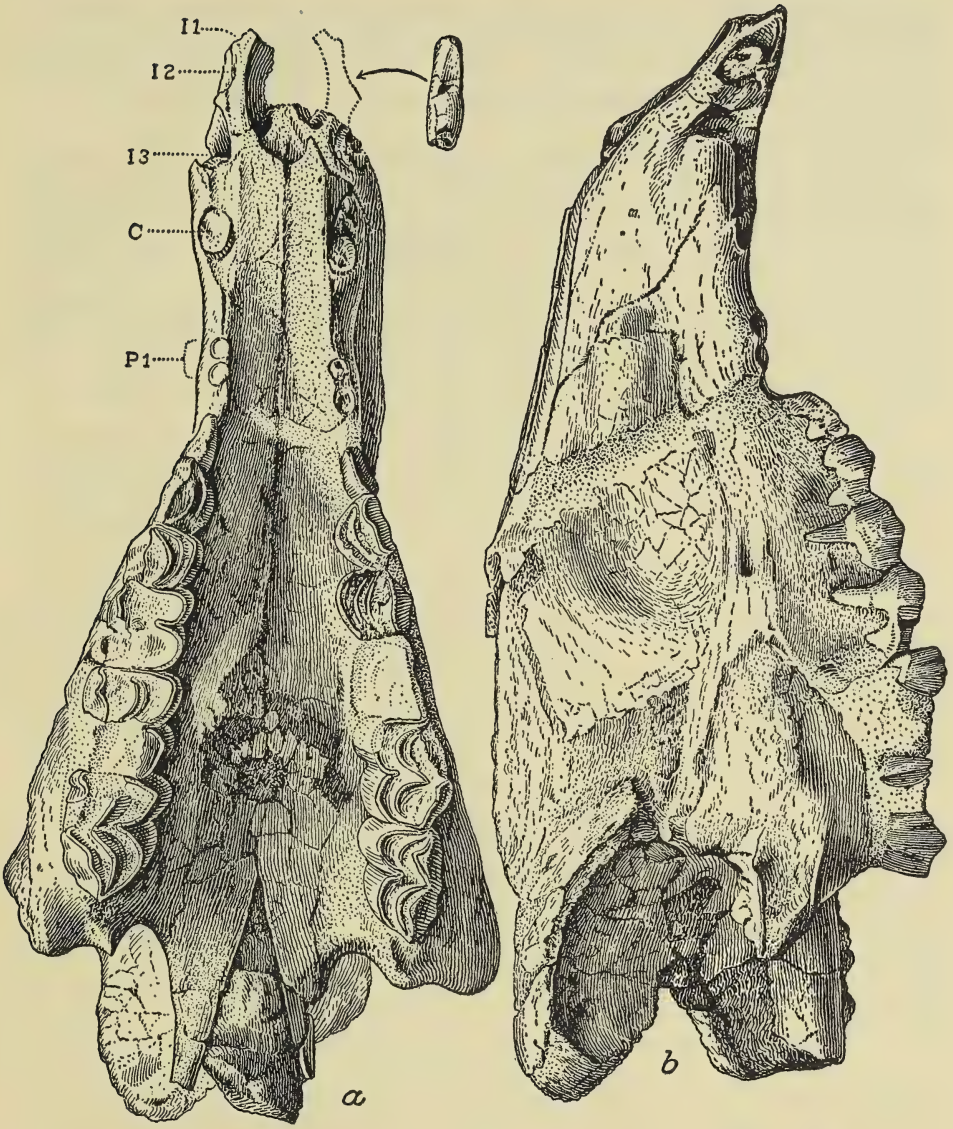

FIG. 15, *a* and *b*—*Miolabis californicus* n. sp. Skull, No. 30046 U.C. Coll., *a*, palatal view, *b*, lateral view; x. 0.75. Mint Canyon Miocene, southern California.

californicus the length from the anterior end of $P\underline{2}$ to the posterior end of $M\underline{3}$ is 82 mm. In *Paratylopus cameloides* (specimen No. 7915 Am. Mus. Nat. Hist.) this measurement is 83 mm.

Pseudolabis dakotensis Matthew [1] from the upper Oligocene (Protoceras beds of South Dakota) is comparable to *M. californicus* in size ($P\underline{2}$-$M\underline{3}$ in the former 83.7 mm., in the latter 82 mm.) although larger than *Pseudolabis (Paralabis) matthewi* Lull. In the genotype the mesostyle is lacking on

[1] W. D. Matthew, Bull. Amer. Mus. Nat. Hist., vol. 20, pages 211-215, 1904.

cheek teeth. The presence of the mesostyle in *P. matthewi* indicates a closer relationship between this species and *M. californicus* than between *P. dakotensis* and the California form. *Pseudolabis matthewi* is smaller and has less quadrate premolars than *M. californicus*. The diastemata are dissimilar.

The presence of the full incisor dentition separates the Mint Canyon form from *Procamelus*. An isolated upper second incisor belonging to No. 30046 is relatively heavy. The exposed section of the root of I$\underline{3}$ shows that the latter was also a large tooth. A striking feature of the diastemata is that the diastema behind P$\underline{1}$ is unusually short as is indicated in the table of measurements. The accuracy of this measurement is somewhat impaired by the presence of a fracture in the skull between P$\underline{1}$ and P$\underline{2}$. The first premolar is definitely and strongly two-rooted. Cope noted that the roots of P$\underline{1}$ in the genotype were discrete at the extremities. In *Protolabis montanus, Procamelus* and *Alticamelus* P$\underline{1}$ is one-rooted.

Protolabis is apparently more advanced in the line of cameloid evolution. The incisors in this genus are much reduced and I$\underline{1}$ may be absent as in a specimen from the upper horizon of the Loup Fork beds doubtfully referred to *P. angustidens*. The premolars are also much reduced, and P$\underline{1}$ is quite small in *P. montanus*.

No. 30046 differs from *M. transmontanus* in some important details. The dentition in the California species appears to be more primitive. The incisors are not spatulate. The dental series is shorter and the reduction of the premolars is not so marked. P$\underline{1}$ is more strongly two-rooted. In *M. transmontanus* the premolar-molar ratio shows relatively greater development of the molars than is the case in *M. californicus*. Important differences are to be noticed in the diastemata. Although the skull itself is smaller, the diastemata behind I$\underline{3}$ and C respectively are longer than those in *M. transmontanus*. On the other hand, the diastema between P$\underline{1}$ and P$\underline{2}$ is much shorter in the California species than in *M. transmontanus*.

Three species of camels from the lower part of the Sheep Creek beds of Nebraska, assigned to *Protolabis fissidens* Cope, *Miolabis longiceps* and *Miolabis tenuis*, are discussed by Matthew.[1] All three of these forms retain I$\underline{1}$ and I$\underline{2}$. Cheek teeth in *P. fissidens* are longer crowned than in *M. transmontanus*. In *M. tenuis* Matthew the muzzle is elongate and slender. The premaxilla is slender anteriorly. Incisors are of moderate size while the canines are small. P$\underline{1}$ is absent except for a small alveolus on one side. Apparently P$\underline{2}$ is absent. Matthew recognizes the wide difference between *M. tenuis* and the genotype and relates it to *M. longiceps* from the Pawnee Creek. In all the characters mentioned above these Great Plains forms differ from *M. californicus*.

The new species does not seem to be closely related to upper Miocene camels and affinity with preceding forms is not clear. *Paratylopus cameloides* does not appear adequate as the ancestral stock of *Miolabis californicus* in view of its deep facial fossæ, elongation of the muzzle, and more pronounced reduction of canines and incisors. In regard to the muzzle, the strongly two-rooted condition of P$\underline{1}$ and size, *M. californicus* appears more primitive than the earlier *Miolabis transmontanus* and hence not derived from this form. *Pseudolabis (Paralabis) matthewi* in shortness of muzzle, spacing of anterior teeth and in general characters of dentition and skull appears as a possible ancestral type. *Miolabis californicus* presumably belongs on a primitive side branch of the Camelidæ which persevered into the upper Miocene.

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[1] W. D. Matthew, Bull. Am. Mus. Nat. Hist., vol. 50, 190, 1924.

Comparative measurements (in millimeters)

	Miolabis californicus No. 30046 U. C.	Miolabis trans-montanus	Paratylopus cameloides No. 10917 Yale P. Mus.	Pseudolabis matthewi No. 10167 Yale P. Mus.
Length, I$\underline{1}$ to M$\underline{3}$	*a*147?	257	....	....
Length, I$\underline{3}$ to M$\underline{3}$	131?	....	....	122
Length, P$\underline{2}$ to M$\underline{3}$	82	92	78.5	....
Length, P$\underline{2}$ to P$\underline{4}$	31.7	35	....	....
Length, M$\underline{1}$ to M$\underline{3}$	50.3	57	....	43.5
Diastema, I$\underline{3}$ to C	9	6	....	5.5
Diastema, C to P$\underline{1}$	13	11	16	15.5
Diastema, P$\underline{1}$ to P$\underline{2}$	*a*6?	20	20	10
P$\underline{1}$, alveolus, anterosposterior diameter	10	....	....	....
P$\underline{2}$, anteroposterior diameter	10	....	....	8
P$\underline{2}$, transverse diameter	4.6	....	....	....
P$\underline{3}$, anteroposterior diameter	12.3	14	....	9.5
P$\underline{3}$, transverse diameter	7	7.5	....	....
P$\underline{4}$, anteroposterior diameter	10.6	....	11	9.5
P$\underline{4}$, transverse diameter	11.1	....	10	....
M$\underline{1}$, anteroposterior diameter	13.2	....	13	12.5
M$\underline{1}$, transverse diameter	13.9	....	....	....
M$\underline{2}$, anteroposterior diameter	17	18	17.3	....
M$\underline{2}$, transverse diameter	15	18	16.5	....
M$\underline{3}$, anteroposterior diameter	19.5	22	20	17
M$\underline{3}$, transverse diameter	16.8	19	17.4	....

a, approximate.

Alticamelus ? sp.

The presence of large camels related perhaps to *Alticamelus* or *Megatylopus* is indicated by an incomplete proximal phalanx, No. 118 C.I.T. Coll. from locality 101. This specimen (fig. 16) is comparatively long and slender, corresponding in shape and size with No. 21563 U. C. Coll. from the Ricardo. No. 21564 U. C. referred by Merriam to *Pliauchenia ?* sp. is relatively shorter and stouter.

A jaw fragment containing one selene of a tooth appears to be that of a large camel. This fragment, No. 119 C. I. T., shows the depth of the jaw to be approximately 38 mm. and the height of the tooth along the inner side of the crescent to be approximately 19.5 mm.

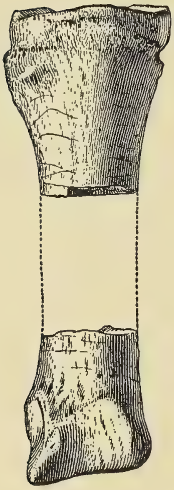

FIG. 16—*Alticamelus ?* sp. Proximal phalanx, No. 118 C.I.T. Coll., anterior view; x 0.50. Mint Canyon Miocene, southern California.

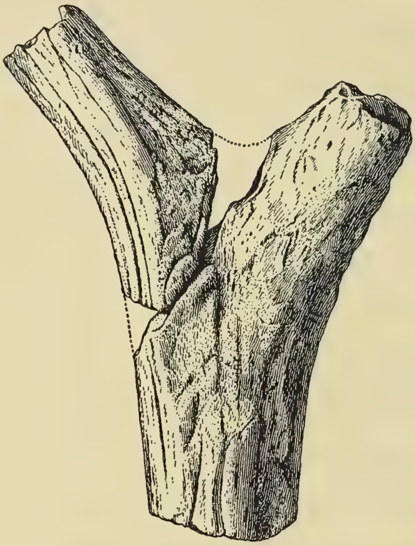

FIG. 17—*Merycodus* near *necatus* Leidy. Fragment of antler, No. 130 C.I.T. Coll.; x 1.0. Mint Canyon Miocene, southern California.

Antilocapridæ

Merycodus near necatus Leidy

Two antler fragments of *Merycodus* showing the region of bifurcation are included in the collection. In No. 130 C. I. T. from locality 103 (fig. 17), the basal portions of the ascending tines are present. Insofar as comparison can be made, this specimen resembles *Merycodus* antlers from the Barstow. In the flattening of the beam, angle of bifurcation of the tines, and in size No. 130 resembles closely material (No. 1399 U. C. Coll.) from the Mohave Miocene referred to *M. necatus*. Toe bones, No. 121 C. I. T., and a fragment of an upper maxillary with a cheek-tooth, No. 122 C.I.T., are referred to *Merycodus*.

Antilocaprid indet.

An enamel fragment of a cheek-tooth indicates the presence of a large antelopine form. The fragment pertains to a selenodont tooth of considerable hypsodonty. Its height is 35 mm. The subdued character of the styles is indicative of affinity with the Antilocapridæ. The two Barstow forms referred to *Merycodus necatus* and *Merycodus furcatus* are much smaller. *? Merycodus altidens* Matthew from the Upper Snake Creek beds is a form of comparable size, as are also members of the genera *Ilingoceras* and *Sphenophalos.*

Oreodontidæ

Oreodont cf. Merychyus

A posterior portion of a left ramus of the mandible from U. C. Coll. Loc. 3555 ? is referred to a small oreodont. The specimen is illustrated in figure 18. The larger part of a worn $M\overline{1}$ and a practically unworn $M\overline{3}$ are present in the jaw fragment. The molars are selenodont and hypsodont. The selenes of the teeth tend to terminate more acutely exteriorly and the valley between them is deeper than in typical cervid or antilocaprid teeth. No prominent style is present on the median inner surface of the tooth as in cervids. The posterior lobe of $M\overline{3}$ does not appear to be as flat as in $M\overline{3}$ of oreodonts. The characters noted are on the whole perhaps more strongly suggestive of an oreodont than of other Miocene artiodactyla.

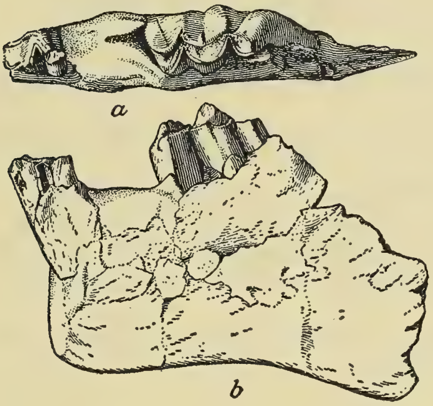

FIG. 18, *a* and *b*—Oreodont, cf. *Merychyus.* Fragment of ramus, U.C. Coll., *a* occlusal view, *b,* lateral view; x 1.0. Mint Canyon Miocene, southern California.

The genus *Merycodus,* somewhat comparable in size, has a thinner and lighter ramus. In the Mint Canyon specimen the ramus increases rapidly in depth beneath $M\overline{3}$. This tendency toward an expanded circular outline of the angle is especially noticeable among the oreodonts. Figures of *Merychyus delicatus* Loomis and *Merychyus paniensis* Loomis illustrate this feature. The Mint Canyon type is somewhat smaller than *M. delicatus.* Teeth from the Virgin Valley beds tentatively referred by Merriam to *Merychyus* are somewhat heavier than those of the Mint Canyon form. The approximate measurements (in millimeters) of the oreodont specimen from the Mint Canyon are as follows: length from anterior end of $M\overline{1}$ to posterior end of $M\overline{3}$, 35; anteroposterior diameter of $M\overline{1}$, 9; anterposterior diameter of $M\overline{3}$, 17; depth of jaw below $M\overline{2}$, 22.

LIST OF MINT CANYON FOSSIL LOCALITIES

All Townships and Ranges referred to San Bernardino Base and Meridian.

All localities in Fernando Quadrangle except No. 97 C.I.T. which is in the Tejon Quadrangle.

University of California:

Locality 3554: SE. ¼ of SW. ¼ sec. 30, T. 5 N., R. 14 W.
Locality 3555: Center of sec. 35, T. 5 N., R. 15 W.
Locality 3564: West line of sec. 35, T. 5 N., R. 15 W.
Locality 3565: S.W. corner of NE. ¼ sec. 36, T. 5 N., R. 16 W.
Locality 3566: N. ½ of NE. ¼ sec. 36, T. 5 N., R. 16 W.
Locality No. not assigned: Center of SW. ¼ sec. 26, T. 5 N., R. 15 W.
Locality 3568: Center of SE. ¼ sec. 30, T. 5 N., R. 14 W.
Locality 3571: N.W. ¼ of SW. ¼ sec. 35, T. 5 N., R. 15 W.

Los Angeles Museum:

Locality 1006: SW. corner sec. 35, T. 5 N., R. 15 W.

California Institute of Technology:

Locality 97: W. line of NW. ¼ of N.W. sec. 14, T. 5 N., R. 16 W.
Locality 98: N. center of SE. ¼ of SE. ¼ sec. 35, T. 4 N., R. 15 W.
Locality 99: Center of SW. ¼ sec. 32, T. 5 N., R. 15 W.
Locality 100: Center of S. ½ of sec. 34, T. 5 N., R. 15 W.
Locality 101: NW. portion of SW¼ sec. 31, T. 5 N., R. 15 W.
Locality 102: N. 1/3 of line between sec. 3 and sec. 4, T. 4 N., R. 15 W.
Locality 103: SW. corner sec. 35, T. 5 N., R. 15 W., same as L. A. Mus. No. 1006.

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